NATURAL RESOURCE CAPITAL IN U.S. AGRICULTURE

Irrigation, Drainage and Conservation Investments Since 1900

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ABSTRACT

This paper gives some original time-series estimates (1900-1975) for the constant-dollar gross and net stocks of public and private fixed capital assets associated with agricultural irrigation, drainage and soil conservation activities (IDC) in the United States. In 1975 the IDC facilities and associated equipment had a real net or depreciated value of $27.5 billion (in constant 1972 dollars). They represent about one-fourth of all fixed nonland capital in agriculture. The $27.5 billion net IDC capital value in 1975 was made up of about $12.3 billion for irrigation (45 percent), $9.7 billion for all conservation (35 percent), and $5.5 billion for drainage (20 percent). The aggregate net value of all IDC capital in 1977 was about $28 billion, weighted 46 percent to irrigation, 20 percent to drainage, and 34 percent to conservation.

Key Words: Natural resource; irrigation; irrigation projects; drainage; conservation; farm capital; resource development.

SUMMARY

The purpose of this paper is to give the findings of an ESCS study of the economic evaluation and growth of agricultural irrigation, drainage and soil conservation in the United States. The emphasis is on capital investments connected with these activities since 1900.

The primary thesis of the paper is that 'natural resource capital', defined as the fixed capital assets associated with irrigation, drainage, and conservation activities (IDC), has the same conceptual standing in agricultural production as labor, land and machinery. Original time-series estimates running from 1900 to 1975 have thus been constructed for the real (constant-dollar) gross and net stocks of public and private fixed capital assets associated with IDC activities in the United States.

Gross capital stocks are accumulated gross annual investments less retirements to date. Net stocks are existing assets reduced in value by the amount by which they have partly depreciated. They may also be called net capital value and net investments to date.

The study employs a 'perpetual inventory' method for deriving capital stock estimates from records of annual investment and estimated depreciation. Except when noted otherwise, all money values given in this paper are standardized to constant 1972 dollars.*

The IDC facilities and associated equipment in 1975 had an aggregate net depreciated real value of $27.5 billion. They now represent about one-fourth of all fixed nonland capital in agriculture. The aggregate net value in 1975 was made up of about $12.3 billion for irrigation (45 percent), $9.7 billion for all conservation (35 percent), and $5.5 billion for drainage (20 percent). A tentative estimate for 1977 of the net value of all IDC capital is $27.9 billion, weighted slightly more toward irrigation than in 1975.

As of 1975, the Federal Government, through direct construction and by cost sharing programs, had created about 45 percent of the net value of all IDC facilities in the United States, varying from 8 percent for drainage, 52 percent for irrigation, and 55 percent for soil and water conservation. About 70 percent of the water management facilities, whether for irrigation or drainage, are of a group-project nature.

Results suggest strongly that drainage and conservation, and particularly soil and water conservation improvements in the United States, are declining in overall book value and probably also in effectiveness. This is because new conservation and drainage investments have not kept pace with estimated depreciation. Drainage facilities increased in value at a steady rate of about 1.3 percent ($60 million) per year in the 30 years from 1940 to 1970. Since 1970 they have slightly declined in value, by about 1/3 of 1 percent ($14 million) per year. General soil and water conservation facilities

*Possible conversions to constant 1975 dollars are explained on page 19. Also, multiplying any of the values in 1972 dollars by 1.75 will very roughly translate them into present (early 1979) dollars. However, this conversion is not suitable for analytical purposes because different components of value must be adjusted differently for price changes. The conversion factor 1.75 (index 175) is a weighted combination of national implicit price indexes for the last quarter of 1978 for all producers' durable equipment (132) and farm structures (179), relative to an index of 100 for the year 1972.

reached a peak net value of $9.9 billion in 1955. Their net value in 1975 was down to $7.9 billion, reflecting an average decline between 1955 and 1975 of $100 million per year. Between 1970 and 1975 the drop was nearly $155 million per year.

Since 1965 the dominant component of IDC capital in the United States has been agricultural irrigation. Until 1941 it was drainage, and between 1941 and 1965 it was soil and water conservation. The aggregate net value of all agricultural irrigation facilities and equipment in 1975 was around $12.3 billion. It is increasing by about $285 million (2.3 percent) per year.

A provisional estimate for 1977 of the aggregate net value of all IDC capital is $27.9 billion, distributed 46 percent to irrigation assets, 20 percent to drainage assets, and 34 percent to conservation assets. These values are also in constant 1972 dollars.

The information from this study is not addressed to any specific class of users, but should be helpful to legislators and other public officials as well as natural resource administrators and planners. Serious students of agriculture may also profit from it, especially those interested in agricultural history, economic structure, capital growth, public expenditure policy, and productivity.

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NATURAL RESOURCE CAPITAL IN U.S. AGRICULTURE
Irrigation, Drainage, and Conservation Investments Since 1900

Introduction and Plan

The purpose of this staff paper is to provide estimates extending from 1900 to 1975 for the 'gross' and 'net' stock of public and private fixed capital assets associated with agricultural irrigation, drainage and soil conservation (IDC) in the United States. These are collectively viewed as natural resource capital. Gross capital stocks in a given year are accumulated gross annual investments for IDC activities less all abandonments or retirements to date. 'Net capital stocks' are existing IDC assets reduced in value by the amount by which they have partly depreciated.

The paper is organized into three progressive yet self-contained parts. Part I reviews the background, methodology and essential results from the research, referring as needed to selected statistical tables. All tables are grouped together in Part II. They are supplemented by an extensive set of interpretive comments and explanations for the various data series presented. Though referenced to the statistical tables, the comments are deliberately more complete than ordinary footnotes. Primary data sources are also identified in many of the tables.

Part III is a more thorough and specialized bibliography of the numerous reference works useful in planning and completing this ESCS natural resource capital study. All are recommended for understanding the significance of natural resource capital accumulation in the development of agriculture in the United States.

PART I: THE STUDY IN BRIEF

Concepts and Background

The concept of natural resource capital guiding this study was that irrigation, drainage, and conservation (IDC) investments and capital stocks physically reflect those aspects of natural resource management that have a determinable or at least a highly plausible relation with agricultural production. More tangibly, they include depreciable improvements to land like conservation terraces and waterways, and irrigation and drainage facilities, whether on or not on farms. Also covered is any durable equipment purchased for irrigation or drainage purposes, like pumps, engines, motors, pipe, sprinklers, and so forth.

The stimulus for the study was some preliminary ESCS research which indicated that public natural resource investments in agriculture had had a modest positive effect on economic growth in agriculture during the 44 years from 1929 to 1972. Such investments accounted for perhaps up to 10 percent of the tendency for Gross Farm Product (GFP) to increase over the period. It was found that, while public resource investments increased an average of 7.25 percent per year from 1929 to 1972, the resource-related partial rate of growth in GFP was around 1.58 percent, giving an elasticity of output with respect to public resource investment of about 0.22 (= 1.58/7.25). In other words, for

an increase of 10 percent in resource investments, and other factors remaining unchanged, annual farm output could be expected to increase by 2.2 percent.

The main factors appearing to be positively related to agricultural growth during the 1929-1972 period were identified as research and extension activities, business inventory accumulations, and investment in producers' durable farm equipment.

As an essential component of a more general study of income and product accounting in natural resource development, it was decided in July 1975 to establish a more complete and detailed set of capital-stock data for natural-resource-related investment activities in agriculture. Chief among the recognized limitations of the original 1929-72 series were the omission of the highly important drainage and irrigation developmental period before 1929, the highly aggregative nature of the series, and its confinement to public expenditures, not all of which could, strictly speaking, be called capital outlays.

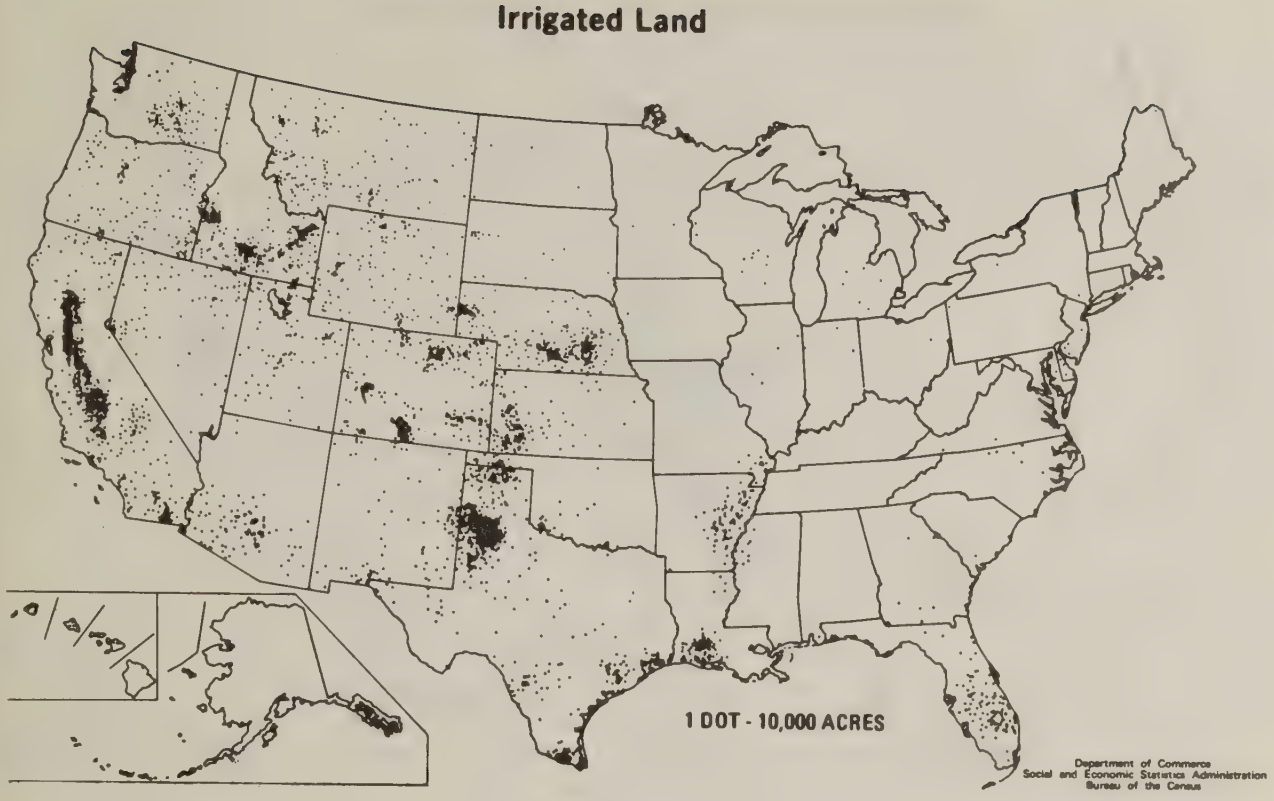
In the new work separate investment and capital stock series extending from 1900 to 1975 were defined for irrigation, drainage, and conservation. These basic series were each divided three principal ways: (a) According to Federal versus non-Federal public and private financing, (b) whether the facilities are farmer-owned and located on farms or of a project nature, and (c) according to the specific legislation under which private investment has been encouraged and Federal participation authorized. The latter breakdown tends to automatically identify the respective program interests of administering Federal agencies and Departments. Considering additional distinctions as to water-supply and land improvements versus equipment per se, and also as to particular types of gravity versus sprinkler irrigation systems, the classification process produced about 45 subseries requiring analysis.

The study was, of course, concerned with regional and State irrigation, drainage or conservation trends, but mainly from the standpoint of developing reasonably reliable aggregate acreages and capital values for the country as a whole. Unfortunately, records of IDC investment outlays for individual States and regions are spotty and of varying quality, so only national totals are given here. On the assumption that capital values bear at least a rough relation to acreages improved or serviced by the IDC facilities, figures 1 and 2 show where irrigation, drainage, and also terracing and stripcropping, two leading types of conservation activities, are presently most concentrated.

General Evaluation Procedure

What is the process by which actual estimates of net capital values can be obtained, particularly when, as in the case of many natural resource assets, conventional markets do not exist? In this work a perpetual inventory approach was followed whenever practicable. 1/

1/ For a more complete explanation and application of the perpetual inventory method, see John C. Musgrave. "Fixed Nonresidential Business and Residential Capital in the United States, 1925-75." Survey of Current Business 56(4):46-52, April 1976. Another extensive treatment, including alternatives to perpetual inventorying, is in Ward's The Measurement of Capital: The Methodology of Capital Stock Estimates in OECD Countries. Organization for Economic Cooperation and Development, Paris. 1976.


Irrigated Land
1 DOT - 10,000 ACRES
Department of Commerce
Social and Economic Statistics Administration
Bureau of the Census

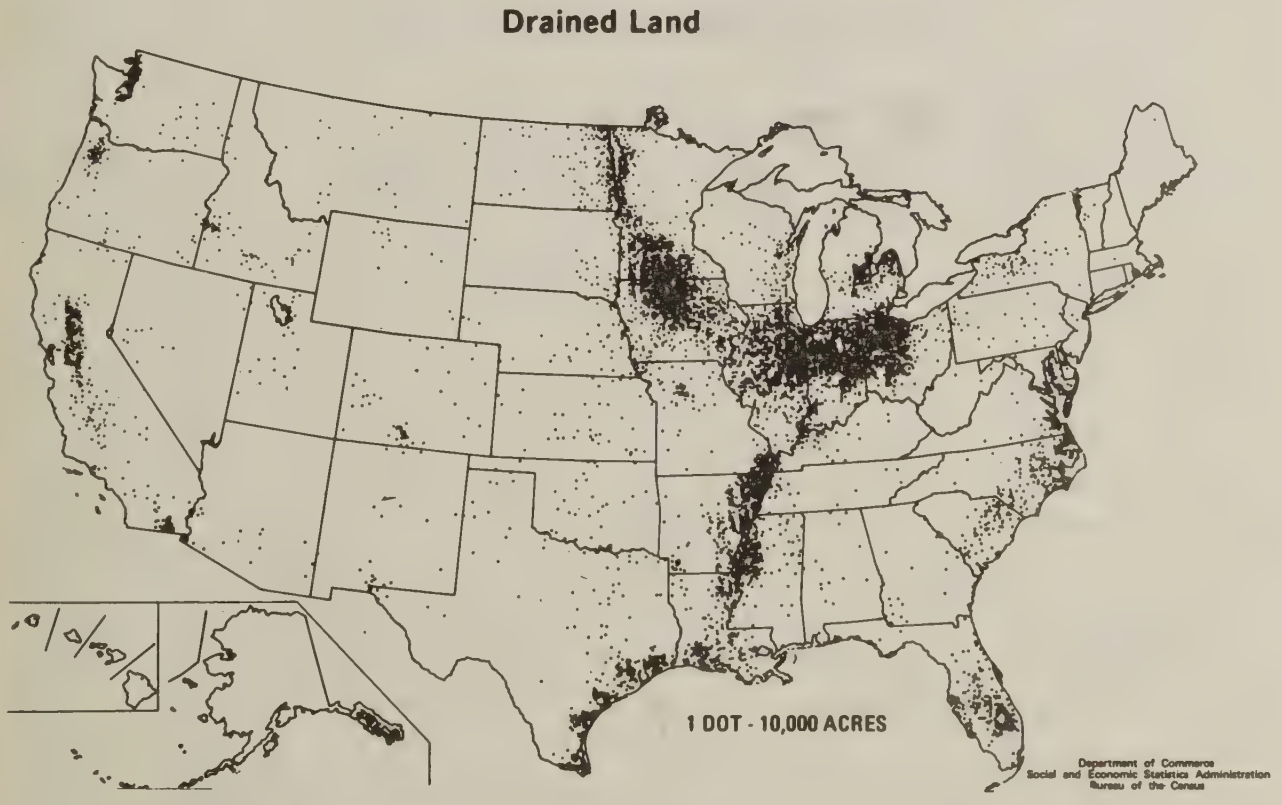
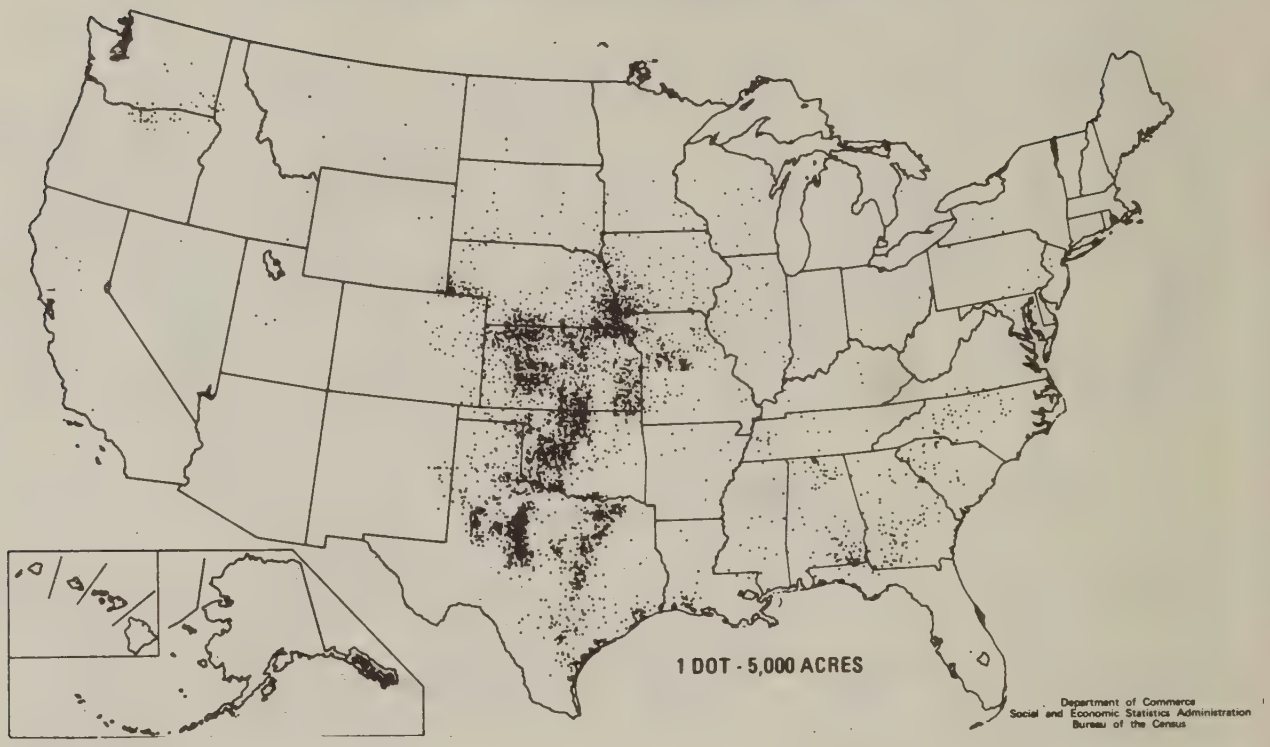

Drained Land
1 DOT - 10,000 ACRES
Department of Commerce
Social and Economic Statistics Administration
Bureau of the Census

Figure 1

Cropland and Pastureland Having Terraces



Stripcropping Systems to Control Erosion

Figure 2

Perpetual inventorying, summarized very generally in figure 3, basically conceives of gross annual investment, in year i, called I_i, as being divided into three parts: (1) the replacement of capital assets sold off as salvage; (2) depreciation on capital assets still in use; and (3) the creation of new capital assets. Gross annual investment I_i occurs spontaneously as investors decide, on their own particular expectations of benefits. Gross investment is independent of depreciation and salvage. Net investment is gross investment less salvage sales and depreciation.

Equations 2 to 5 in figure 3 relate past investment, as added up in equation 1, to the economic values of physical capital still in use at a particular time. Gross stocks (equation 2) are all past investments not yet retired. They are carried at their full original cost. Net capital stocks (equation 5) are the accumulated net additions to capital. They amount mathematically to ΣI_i, the algebraic sum of annual net investment rates. These may have been positive or negative, depending on whether gross investment in each year was above or below depreciation charges and salvage sales for that same year.

Changes over time in the purchasing power of the dollar were allowed for in the work by deflating all values to constant dollars; that is, to the price levels prevailing in some base period, selected here as the year 1972. When deflated, the gross and net stocks can be interpreted the same way as physical magnitudes and directly compared with labor and other inputs, and also corrrelated with production quantities and deflated production values. In this standardized context the cost of reproducing all existing assets at prices of the base year is called the 'real gross stock' of a particular type of capital. The 'real net stock' is the depreciated net value of the real gross stock, allowing for the fact that to various degrees existing assets have depreciated in value through use, damage or obsolescence.

By implication depreciated or net stock values are also measures of the net value of future productive services still inherent in capital assets. The net values are indicative of the price at which the assets might be sold in a market setting, recognizing that separate markets may not exist for certain types of productive assets, particularly if they are appurtenant to land and thus salable only as a part of real estate.

Price levels for the year 1972 were adopted so that the estimates for IDC capital developed in this study could be compared and merged with other national data on stocks of capital in the industrial and other nonagricultural sectors of the economy, such as those prepared by by the Departments of Agriculture and Commerce and other organizations in their ongoing studies of national wealth. Using 1972 price levels also makes the estimates from the study consistent with the National Income and Product Accounts (NIPA) for the United States. In January 1976 the Bureau of Economic Analysis in the Department of Commerce began to release its benchmark revisions of annual and quarterly NIPA data for the United States for the period 1929-1975. 2/ An important feature of the Bureau's revision was the shifting and revamping of all historical and future constant-dollar NIPA estimates to the year 1972 as a new valuation base.

2/ The complete revised accounts, including those for agriculture, have since been published in The National Income and Product Accounts of the United States, 1929-74: Statistical Tables. Supplement to the Survey of Current Business. 1977. Government Printing Office, Washington, D.C.

PERPETUAL INVENTORY MODEL

Gross investment over n years:

ΣI_i, ($i = 1, 2, \ldots, n$, here and below) (1)

Gross capital stock after n years, or Q_n:

$Q_n = \Sigma I_i - \Sigma R_i$, with R_i the assets retired in year i (2)

Depreciation in year i, or D_i: (3)

$D_i = f(Q_{n-1}, d)$, with d the constant or functional depreciation rate in each case. That is, depending on the method of depreciation employed, d may be a fixed or varying amount (or percentage) of the gross or net capital stock as of the end of the previous year.

Capital sold as salvage in year $i = pR_i$: (4)

The coefficient p is average salvage value as a fraction of original cost. When capital is retired it is deducted from the gross capital stock at its full original cost. It is also deducted from the net capital stock, but only at its salvage value.

Net capital stock after n years, or Q_n':

$$Q_n' = \Sigma I_i - \Sigma pR_i - \Sigma D_i = \Sigma I_i' \quad (5)$$

where I_i' is the annual rate of net investment in year i.

Figure 3

Procedural Problems and Assumptions

While perpetual inventorying was quite useful as an overall guide for capital stock measurement, its applicability in practice depended on the kind of appraisal situation represented by each type of irrigation, drainage and conservation asset, and particularly on the specific manner in which such assets are considered to depreciate. Some procedural implications and assumptions underlying the empirical results thus need to be discussed first.

This study of natural resource or IDC capital growth from 1900 to 1975, by definition, deals with observed rather than assumed information on investment and related variables. Apart from the substantial effort involved in locating and properly evaluating relevant historical data on IDC investments, the historical approach implies a lack of freedom to evaluate randomly changing annual investment data via systems of formulas like those commonly seen in the literature of economics and finance. In textbook discussions investment and depreciation are almost always taken to be constant or to systematically change. Sometimes their behavior is expressed as mathematical functions of time. This 'formula approach' is applicable primarily to projective appraisals of capital growth based on expected rates of investment, depreciation and on related technological and institutional assumptions, all of which are subject to varying degrees of uncertainty and probable error.

It would be untrue to claim that our historical analysis of IDC capital growth, by dealing with observed rather than projective data, avoided many uncertainty and measurement difficulties. Records of investment in irrigation, drainage and conservation, even when found available, have been set up and maintained to serve legislative, public-information and administrative purposes, not scientific purposes. Research classifications had to conform to these realities as well as recognize usual differences in the quality and completeness of historical records.

A second procedural difficulty was connected with the objective of estimating changes in net capital values. It was the virtual nonrecognition of depreciation in available Census and other governmental information on IDC activities. This required a resort to the literature and personal judgments on appropriate depreciation methods, useful lives of assets and other variables that critically influence net capital stocks.

A third problem was connected with measuring IDC investments and capital stocks in constant dollars. It was the nonavailability of 'official' price indexes specific to some important types of IDC assets. Acceptable deflators for major irrigation and drainage works installed by public agencies like the Bureau of Reclamation, and perhaps by quasi-public irrigation and drainage organizations, were available from their own reports and planning manuals, other public documents, trade sources and engineering texts. For a few other items, like farmer-owned irrigation equipment, it was possible to borrow comparable available indexes for similar assets, like durable farm equipment. However, no reasonably comparable deflator series existed for irrigation, drainage and conservation improvements and facilities installed on farms by farmers alone, nor for those installed jointly by farmers and public agencies under cost-sharing programs. Here it was necessary to improvise and make the conversions to constant dollars using various combinations of available labor cost, materials, and construction cost indexes.

These assumptions as to deflation combined with the range of assumptions in calculating depreciation are clearly the most important determinants of the

differences between current-dollar and constant-dollar rates of gross and net investment, and of gross and net stocks of agricultural natural resource capital in the United States since 1900. Accordingly, a summary of 'depreciation' methods and assumptions pertinent to the major IDC categories follows:

Project Irrigation and Drainage Facilities

Depreciation on project facilities was not calculated by any formal method against existing capital values. Rather, it was treated as a deduction from gross annual investment. The Bureau of Reclamation (BREC) and other irrigation and drainage organizations do not ordinarily maintain depreciation accounts, mainly because of the intended permanence of their facilities and the particular institutional and legislative conditions under which they function. The proxy measures for depreciation of BREC irrigation facilities were the investment in rehabilitation programs. Between 1949 and 1975 these totaled about $75 million in current dollars, deflated to $100 million in 1972 dollars. From 1903 to 1948, BREC rehabilitation expenditures were quite minor and not a specific line item in agency accounts. For this study gross and net stock values of BREC irrigation works and equipment between 1903 and 1948 were thus considered to be the same.

For project irrigation facilities other than those owned by the Bureau of Reclamation and for all project drainage, the measure of depreciation was the portion of gross annual investment, as reported since 1870 in the Censuses of Irrigation and Drainage, used for the replacement of existing facilities as opposed to expenditures for new facilities. The reasoning behind this procedure, which was applied to all project irrigation and drainage facilities, was that rehabilitation and replacement costs impose a demand on annual investment budgets but create no new capacity. Formally calculated depreciation has an analogous meaning.

Operation and Maintenance (O&M) accounts were considered but discarded as sources of depreciation information. Typically, there is no effort for project organizations to separately budget report the two components. Since the bulk of the expense is for operations per se, latent errors in the capital stock values are probably quite minor. Another point to remember here is that maintenance expenditures are themselves as subject to subsequent depreciation as the initially created assets. In future work these questions will be examined more closely. 3/

3/ In reviewing a draft of this report and discussing depreciation of its facilities, the Bureau of Reclamation pointed out that rehabilitation programs are undertaken when annual maintenance expenditures are becoming excessive. The programs thus do not account for the entire amount of depreciation in irrigation facilities. The Bureau also noted that, in some cases, a portion of the operation and maintenance cost could justifiably be used as a proxy for depreciation, since continued failure to perform maintenance functions would result in the failure of irrigation systems. Dredging of distribution canals and laterals is a good example.

On-farm Irrigation and Drainage Facilities

On-farm irrigation facilities include land leveling, other field preparations, wells, ponds, stream-diversion works, turnouts, ditches, and so forth; that is, any durable feature of a farm irrigation system other than durable equipment. Equipment as such is discussed below. On-farm gravity irrigation facilities were assigned useful lives ranging between 15 and 25 years and depreciated by the straight-line method.

On-farm drainage improvements were assigned an average useful life of from 20-25 years with no salvage value and then depreciated at a straight-line rate of between 4 and 5 percent per year of the initial cost. The assumed maximum life of 25 years for either on-farm irrigation or drainage facilities may appear unduly short. However, it recognizes that income tax laws have permitted some accelerated depreciation of irrigation and drainage works and thereby have encouraged early replacement with improved systems and materials.

Farmer-owned Irrigation Equipment

This category includes items like pumps, power units, pipe, siphon tubes and various components of farm sprinkler irrigation systems. A special analysis of sprinkler irrigation equipment investments since 1940 was necessary to construct an accurate time series on irrigation equipment stocks in general. While straight-line depreciation was assumed on all types of irrigation equipment, assumed useful lives varied according to the particular type of equipment and associated water-supply improvement involved. An abbreviated list of depreciation periods follows: Permanent complete sprinkler installations (25 years); solid-set portable sprinkler systems (12 years); self-propelled center-pivot sprinkler systems (15 years); irrigation wells and stream improvements (25 years); pumps (20 years); electric motors (20 years); diesel, propane and natural gas engines (15 years); gasoline engines (9 years); irrigation pipe (5-40 years), depending on materials, size and use; and sprinkler heads (4-8 years), depending on materials and design. 4/

Soil Conservation and Land Protection

Annual current-dollar private and governmental investments in farm conservation and watershed land protection were first converted to constant dollars, then summed to obtain gross capital stocks (allowing for retirements), and then depreciated to obtain the net capital values. Ordinary maintenance was regarded as an operating cost; it was not counted against gross investment. However, major or non-ordinary maintenance frequently occurs as substantial improvements and supplementary treatments. These may again qualify for Federal cost-sharing. Such 're-application' expenditures were counted as part of annual conservation investments and depreciated.

4/ For more information on depreciation and the estimated service life of numerous components of irrigation systems see the handbook Sprinkler Irrigation (eds. Claude H. Pair and others), 3rd ed. Sprinkler Irrigation Association, Washington, D.C. 1969; also see Sprinkler Irrigation, by Arthur F. Pillsbury and Ariosto Degan. Food and Agriculture Organization of the United Nations (FAO), Rome, 1968.

Service lives for straight-line depreciation purposes varied primarily according to the type of land treatment and structural improvement involved, guided partly by the legislation authorizing joint Federal and private financing. Conservation measures administratively regarded as 'temporary' were excluded altogether. Assumed service lives for permanent conservation land treatment measures ranged between 10-15 years if they were installed under either the Rural Environmental Assistance Program (formerly ACP), or the Watershed Protection and Flood Prevention Act of 1954 (P.L. 83-566). If installed under the Great Plains Conservation Program, authorized in 1956, permanent conservation measures were assigned an average useful life of 17 years. All structural measures for land protection, irrigation or drainage installed under the P.L. 566 watershed program were assumed to have at least a 50-year service life.

Results and Discussion

This review and discussion of statistical findings from the study draws selectively from the detailed tables given in Part II.

Trends for Major Capital Classes

The role of irrigation, drainage and conservation (IDC) capital since 1900 in the overall farm capital picture is documented in a general way in tables 1 and 2. The changing rates at which such capital has evolved via investment are shown in table 15. The study considered the IDC assets to be part of fixed physical capital in agriculture, along with producers' durable equipment, residential structures and nonresidential structures. Livestock and crop inventories are part of physical capital too. As in other sectors of the economy, annual changes in business inventory holdings are an element of gross private domestic investment. The largest category of farm physical capital is land. The values derived for land per se in table 1 are aggregate farm real estate values in constant 1972 dollars less the values shown for residential and nonresidential buildings.

Trends in the real net value of farm physical capital and its major components since 1900 are also evident in tables 1 and 2. The land input has risen by an almost uniform 1/5 percent per year but, excepting the period from 1920 to 1925, its importance compared to inventories and most fixed capital has fallen--from about 80 percent of all physical farm capital in 1900, to 66 percent in 1935, down to about 50 percent in 1975. 5/ Farm business inventories, mostly livestock and livestock feed, have grown moderately but steadily in importance. They have increased in net value by an almost constant 1.1 percent each year between 1900 and 1975, rising from 10 to 13 percent of farm physical capital.

Tables 1 and 2 show also that fixed capital has been the most variable and substituted component of physical capital in agriculture. Its growth and

5/ Refer to T.W. Schultz for a still timely and thorough study of the changing significance of land as a factor in agricultural production. See 'The Declining Economic Importance of Agricultural Land', ch. 8 in his text The Economic Organization of Agriculture. McGraw-Hill Book Co. 1953.

decline since 1900 closely parallel national economic conditions generally prevailing at the time. There was accelerating disinvestment through the farm depression years 1920-1935. This was followed by recovery, especially in the years immediately following World War II. In the interval from 1931 to 1935, the real net value of durable equipment and nonresidential farm structures declined an average of 5 percent ($1.16 billion) per year, in constant 1972 dollars. The rebound from 1946 to 1950 was nearly 12 percent ($3.06 billion) per year.

Results for Natural Resource Capital

Net value data for natural resource capital assets by 5-year intervals since 1900 are given in table 3, in the aggregate and separately for each IDC component--irrigation, drainage and conservation. Average annual net investment rates are in table 15. Cumulative gross investments to date are in table 16. All these net capital values and annual net investment rates are also given in constant 1972 dollars.

In 1975 the irrigation, drainage, and conservation facilities and associated equipment, had a combined net depreciated value of $27.5 billion. They currently represent about one-fourth of all fixed nonland capital in agriculture. This aggregate net value was made up of about $12.3 billion for irrigation (45 percent), $9.7 billion for all conservation (35 percent), and $5.5 billion for drainage (20 percent).

Table 3 also shows the breakdown since 1900 of all IDC capital into its Federal and non-Federal components. As of 1975, the Federal Government, through direct construction and indirect cost sharing, had created about 45 percent of the net value of all IDC facilities in the United States. This varied from 8 percent for drainage, 53 percent for irrigation, and 55 percent for soil and water conservation. The overall Federal involvement was clearly greatest in the Depression and World War II years. It focused mostly on farm conservation and irrigation projects, particularly those irrigation water storage projects where hydropower capacity could also be obtained for military and industrial purposes. The recent (1971-75) cut-backs in Federal soil conservation and water development efforts are particularly noticeable, though much of this real decline can be attributed to inflation.

Also as of 1975, about 70 percent of the water management facilities, whether for irrigation or drainage, were of a group-project nature. It is important to remember that project facilities for irrigation and drainage can be either privately, publicly, or quasi-publicly created and owned. Conservation facilities typically involve individual farms, although some have been installed through pooling agreements among landowners and conservation agencies. These overall findings will be discussed more completely with respect to drainage, conservation and irrigation, the order corresponding to their historical importance. Values are expressed in 1972 dollars unless indicated otherwise.

Farmland Development Drainage.--In terms of acreage even to the present time and in terms of capital values until 1945, farmland drainage has been the primary agricultural water management and farmland reclamation activity in the United States. The years between 1905 and 1915 were the peak period for farmland drainage projects, A secondary surge occurred between World War I and the Depression. Farmland drainage facilities increased in value

at a steady rate of about 1.3 percent ($60 million) per year in the 30 years from 1940 to 1970. They have since shown a slight decline in value, of about 1/3 of 1 percent ($14 million) per year.

Nonproject drainage also began quite rapidly in the early 1900's. It remained fairly static from 1925 until World War II when, along with on-farm irrigation, it began to be included for cost-sharing eligibility in agricultural conservation programs. The post-war renewed interest in drainage continued until about 1965. It was manifested in some important new drainage reclamation projects, especially in the Lower Mississippi Valley and other parts of the South. At the present time, however, individual farm drainage systems are growing much more rapidly than large scale drainage projects.

The fairly low and recently negative overall net investment rates for drainage, by necessarily allowing for depreciation of all existing drainage facilities, tend to conceal the importance of these activities. For example, depreciation on all existing agricultural drainage works in the United States averaged $55 million per year between 1971 and 1975. The average annual net investment rate for drainage for that period in table 14 is given as minus $15 million. From the relation Net Investment = Gross Investment - Depreciation, gross drainage investments between 1971 and 1975 really averaged $40 million per year. See equation 5 in figure 3.

While statistically much less important than farmland development through drainage, capital values for those major drainage works installed in conjunction with irrigation projects, and those made necessary by unanticipated water-logging of irrigation project and adjacent lands, were also determined as part of this study. Acreages involved and capital values are in table 12. Such irrigation-associated drainage capital is included with irrigation only. For some purposes it could be counted legitimately both ways--for irrigation and drainage.

Soil and Land Conservation.--One of the most suggestive findings of this study of natural resource capital in agriculture is that soil and water conservation improvements on U.S. farms, which experienced rapid expansion from 1935 to 1955, are now deteriorating in overall value and probably also in effectiveness (tables 3, 13 and 14). Their peak net value of $9.9 billion was reached in 1955. Their net value in 1975 was down to $7.9 billion, the result of a decline between 1955 and 1975 of 1.1 percent ($100 million) per year. From 1970 to 1975 the drop averaged nearly 2 percent ($154 million) per year.

Since 1954, disinvestments in general soil conservation have been partly offset by conservation and land protection improvements installed since under the Watershed Protection and Flood Prevention Act. The net value of these special conservation facilities in 1975 was about $1.8 billion. Their increase was about $115 million per year between 1955 and 1970; it then dropped to around $25 million per year.

The findings for conservation capital mean that new conservation investments, when deflated to real dollars, have not kept pace with estimated depreciation. The recent budgets for the Rural Environmental Assistance Program have likely suffered the most in this respect, although the Great Plains and Watershed Programs for soil and land conservation also seem to have lost impetus, at least when inflation is considered.

The rise and recent decline of conservation capital in agriculture are shown most clearly by table 14. It gives average annual net investment

(growth) rates by 5-year periods since the initiation in 1935 of soil conservation cost sharing programs. The programs expanded rapidly right on through World War II. However, since the peak year 1955 ($9.9 billion), the real value of conservation improvements has actually fallen, owing to annual net investments becoming negative. As explained elsewhere in this report, annual net investment will be negative and net capital values will fall when annual depreciation charges exceed gross new investment.

Agricultural Irrigation.--Recent investment rates for irrigation contrast sharply with those for conservation and drainage. Irrigation in the United States had a growth pattern strikingly similar to that of drainage up until about 1920 (tables 3, 5 and 14). Some important private irrigation projects were initiated between 1880 and 1900, then public project development was given a strong push by the Reclamation Act of 1902.

Non-Federal net investment rates for irrigation were actually negative from about 1920 to 1935 but thereafter were reversed and gained rapidly. Farmer-financed and non-Federal project net investments in irrigation have exceeded Federal investments since about 1960. Nearly all Federal inputs to irrigation development are planned and executed through the Bureau of Reclamation in the Department of the Interior. Activities of the Department of Agriculture are essentially limited to technical assistance, loan programs for irrigators and some cost sharing for land preparation.

Irrigation is definitely the current and foreseeable heavyweight in the natural resource capital picture. At the beginning of World War II irrigation facilities were still considerably outranked in value by drainage facilities. By 1945 irrigation had permanently passed drainage. It passed conservation in importance by about 1965. The aggregate real value of all irrigation facilities and equipment in 1975 was around $12.3 billion.

To give equal treatment to types of facilities and methods of financing, the growth of irrigation capital by financing source, location and types of facilities is shown in table 5. As of 1975, the Federal government had created about 53 percent ($6.4 billion) of the Nation's fixed capital investment in agricultural irrigation. The remaining 47 percent ($5.8 billion) represented individual farmer and non-Federal project investments. More recent developments suggest that this percentage split is now about 50:50.

Also as of 1975, project irrigation facilities and equipment, including both Bureau of Reclamation and non-Bureau projects, accounted for 72 percent of all irrigation capital. The remainder represented on-farm irrigation improvements, water-supply investments, and farmer-owned irrigation equipment. Table 5 indicates that this component has been increasing rapidly, averaging on the order of $160 million (5.3 percent) per year between 1970 and 1975.

It was not a purpose of this study to investigate the many factors explaining the growth of irrigation and consequent changes in the composition of natural resource capital, particularly since World War II. However, five likely triggers were: (1) The War itself, which called for a great increase in agricultural production and its expansion, especially cotton, into the arid West; (2) general advances in production methods, including fertilizer use. These tend to make supplemental water application more profitable too; (3) some widespread humid-region droughts from about 1955 to 1965. These helped advertise and permanently establish irrigation as a production alternative in many new areas; (4) a generally steady improvement in real farm income and operator equities. This has encouraged more investment, including own-account

investment, in farm equipment and capital facilities; and (5) important changes in the technology of irrigation itself. Most of these were intended to simplify the adoption of irrigation, especially to reduce labor requirements.

Technological changes in irrigation have caused farm as well as project irrigation to become highly capital-intensive. Since 1965, on-farm investments in sprinkler irrigation have exceeded those made for gravity irrigation According to table 8, gravity irrigation capital is actually declining, although on an acreage basis gravity irrigation is still quite predominant.

Finally, sprinkler irrigation itself has undergone important and very rapid changes. In the five years from 1970 to 1975, for example, the fraction of all capital in sprinkler distribution systems represented by costly mobile and self-propelled sprinkler units rose from about 27 to more than 46 percent. Tables 8, 9 and 10 contain more specific information on changing sprinkler irrigation technologies and capital values.

Additional Comments on Sources of Financing

Sources of financing and location are both very useful in judging the significance of natural resource capital in agriculture. To repeat, as of 1975 the Federal Government, either by direct construction via the Bureau of Reclamation or by indirect cost-sharing, had created about 45 percent of the net value of all IDC facilities. This varied from 8 percent for drainage, 52 percent for irrigation, and 55 percent for soil and water conservation facilities. Concerning location, about 70 percent of the water management facilities, whether for irrigation or drainage, are of a group-project and off-farm character. They are a very significant part of agriculture's infrastructure.

These figures are purely descriptive. Causative and normative aspects are largely avoided. 6/ It is often argued that the criteria underlying investment decisions differ in the private and public sector. For example, private decisions are based on private profitability while public decisions are based on long-term social needs. But in recent years at least, it would appear that expected 'profitability', however measured, is a common criterion for public and private IDC investments. It is the expectational factors that are different, like different levels of acceptable risk, different funding arrangements, and different competing alternatives.

This study does not indicate that public investments of a developmental tal nature in the agricultural sector are necessarily higher during periods of international stress and uncertainty or when domestic economic conditions are sluggish and depressed. Federal conservation investments per se did occur mostly during the Depression and World War II. They appear to have actually reached their maximum annual net rate of about $400 million per year during World War II (table 13). On the other hand, Federal investments for irrigation development have not only continued at fairly high levels since 1925, but peaked at an average of $173 million per year from 1960 to 1965 (table 5).

6/ In reviewing an earlier draft of this report, Emery N. Castle of Resources for the Future pointed out that the proportions of private and public investment in various IDC categories may have been influenced significantly by the fact that public-sector investment has its own set of justifying criteria. Some interpretation has been added here to at least tentatively examine the results of the study in relation to his hypothesis.

Federal investments for farmland drainage have been quite modest and confined for the most part to the period from 1945 to 1965, peaking at $22 million per year between 1955 and 1960 (table 11).

Further, the study does not show that private IDC investments have varied either directly or inversely with public investment. It is true that, with respect to conservation and because of cost-sharing programs, private investment can depend on Federal financial as well as technical assistance. However, this does not mean that, under a 50:50 cost-sharing policy for example, an additional dollar allocated to cost-sharing budgets will result in two dollars of total expenditure. It would be more accurate to say that actual public investments have depended on three sets of factors: (1) Congressional allocations of public funds to different conservation programs; (2) actual administrative (Departmental) allotments to specific qualifying practices and improvements; and (3) the degree to which farmers actually participate in the programs, by being willing to make the changes that qualify for financial assistance. In other words, even where installation costs are shared, actual Federal expenditures depend in the final analysis on the level of private expenditure and participation.

Where investment costs are not immediately shared, as for major irrigation works built independently by the Federal Government with future repayment required from farmers, private expenditures are not only deferred but are also dependent on private expectations of profit, access to funds and the various other conditions that normally govern private investment decisions. The information used and generated in this study suggests that, unless IDC investment costs are simultaneously shared by the private and public sectors, and in some definite and significant proportions, private and public investment will occur fairly independently and for different reasons.

Interim IDC Estimates for 1977

The long-term historical information developed in this study ends with the year 1975 because 'official' cost indexes, public expenditure data, and consequently, estimates of gross and net real investment and capital stocks, have an availability lag of at least 2-3 years. All the same, some very tentative updates to 1977 for IDC net capital stocks, based on trends from 1971 to 1975 and spending estimates for 1976 and 1977, are as follows:

Types of IDC capital	Net capital stocks (Constant 1972 dollars)		Average annual change from 1975 to 1977	
	Net value in 1975 $Bil.	Net value in 1977 $Bil.	Net investment rate $Mil/yr.	Percent rate %/yr.
Irrigation	12.265	12.840	287	2.3
Drainage	5.500	5.480	-10	-0.2
Conservation	9.700	9.600	-50	-0.5
All types	27.465	27.920	227	0.8

This brief table suggests strongly that drainage and conservation, particularly on-land soil conservation improvements, are deteriorating in overall real value and probable effectiveness, because new conservation and drainage expenditures are not keeping pace with ongoing depreciation.

Drainage facilities increased in value at a fairly steady rate of about 1.4 percent per year in the 25 years from 1945 to 1970. They have since shown a slight decline in value--of about 1/3 of 1 percent per year. Their net capital value in 1977 was about $5.5 billion. The annual decline in 1976 and 1977 appeared to have slacked off a bit, to an average of about 0.2 percent.

Losses in the value of conservation facilities have been more severe. Their peak value of $9.9 billion was reached in 1955. Their net value in 1977 was $9.6 billlon, the result of an average decline between 1955 and 1977 of nearly $14 million per year. Between 1970 and 1975, however, the decline was nearly $155 million per year. The average decline for 1976 and 1977 appears to have been on the order of $50 million (0.5 percent) per year.

The current and foreseeable-future heavyweight in the natural resource capital picture is agricultural irrigation. During World War II irrigation facilities were outranked in value by both conservation and drainage facilities. By 1945 irrigation had passed drainage in importance. By 1965 it had also passed conservation. The aggregate net value of irrigation facilities and equipment in the United States is presently increasing by about $285 million per. In 1977 it was close to $13 billion.

Extended Uses of the Study

Eventual uses of this ESCS study of natural resource capital growth cannot be foreseen completely, but some possibilities can be outlined under history, economic structure and methodology. As history the information can improve our understanding of the changing importance of different modes of resource development in agriculture and the total economy, and the probable future size and composition of capital resources relative to labor and other inputs. The work also helps in evaluating the condition of our natural environment which, in many localities, is represented by the condition of agricultural land and associated conservation and other capital improvements. The derivation of real investment rates and capital values should also facilitate studies of the merits of public programs for resource conservation and development, granting that action-agency yearly appropriations often reflect changing national priorities and policical moods more than appraisals of benefits and increased costs. An evaluation of this nature in the Department of Agriculture, recently mandated by the Congress, is described a few paragraphs forward in this paper.

Concerning economic structure, numerous improvements in national economic statistics and accounts for the agricultural sector prepared periodically by the Department of Agriculture and other agencies have been proposed by Carlin and Handy, Penson, Simunek, Spielmann, Weeks and others. 7/ Carlin and Handy,

7/ All references here are to a group of related recent articles in the American Journal of Agricultural Economics: Thomas A. Carlin and Charles R. Handy, "Concepts of the Agricultural Economy and Economic Accounting", December 1974; Heinz Spielmann and Eldon E. Weeks, "Inventory and Critique of Estimates of U.S. Agricultural Capacity", December 1975; Richard W. Simunek, "National Farm Capital Accounts", August 1976; John B. Penson, Jr., "Toward an Aggregative Measure of Saving and Capital Finance for U.S. Farm Operator Families", February 1977; and Penson with Dean W. Hughes and Glenn L. Nelson. "Measurement of Capacity Depreciation based on Engineering Data", May 1977. Complete citations are in the first section of Part III, except for Spielmann and Weeks (in the third section).

for example, point out that the family-farm approach only partly determines the commitment and contribution of labor and capital to agricultural output, and inevitably to the share of GNP originating in agriculture. Simunek notes that under present accounting rules certain outlays that represent investment and capital formation are instead treated as current expense, and that fixed capital improvements to land, like the IDC facilities evaluated in this study, are not depreciated like other fixed assets. Further, Penson and associates question the appropriateness of assumptions and techniques that underlie 'official' depreciation and capital stock estimates for machinery and similar fixed assets.

By recognizing and calculating IDC depreciation and adding IDC capital values both on and off farms and ranches to the commitment of familiar agricultural capital like equipment and buildings, this study of natural resource capital growth in agriculture significantly improves our knowledge of economic structure. The agricultural sector is represented more realistically by isolating additional relevant forms of public and private investment, capital consumption and net investment. The idea here is that if natural resource likely be most successful if unified. Another suggestion is to watch the technological horizon and to begin monitoring actual investments in successful innovations as soon as possible, not waiting until they are 'significant' and part of some policy problem.

An Addendum

This ESCS study of long-term natural resource capital growth in agriculture was initiated in July 1975. Final results became available in July 1977, due to the excellent cooperation of the Bureau of Reclamation (Department of the Interior), the Agricultural Stabilization and Conservation Service, and the Soil Conservation Service. The information on irrigation, drainage and conservation investments has since been widely used by State and local governments, industry and academic officials.

In December 1976, while this ESCS study was in process, it developed that the Senate Committee on Agriculture, Nutrition and Forestry requested the Secretary of Agriculture to initiate an official evaluation of all land and water conservation programs funded or otherwise administered by the Department of Agriculture. Although eight different USDA agencies are officially involved in such programs, the activities are actually supervised only by the Agricultural Stabilization and Conservation Service, Farmers Home Administration, Forest Service, and Soil Conservation Service. The evaluations were to determine: The extent to which program and legislative objectives are being met; program impacts in the context of national conservation policies; efficiencies in administration; and whether program purposes and mechanisms remain valid considering present and projected conservation needs. Information on past expenditures, like that developed in the ESCS study, is vital to all of these determinations.

In late 1977 the Secretary of Agriculture transmitted a preliminary official report to the Senate Committee. The report was assembled by an Initial Report Team (IRT) representing the eight concerned USDA agencies, including ESCS. 8/

8/ Since released by USDA under the title Initial Report on the Land and Water Conservation Program of the U.S. Department of Agriculture. December 1977, 97 pp. mimeo.

The IRT analysis detailed the statutory and other authorizations underlying the Department's conservation responsibilities and programs. It reviewed accomplishments and related research efforts since inception of the programs in the mid-1930's. Funding histories since 1935 were reconstructed in the IRT report for nine separate programs. At least three of these--ACP conservation cost-sharing, watershed protection, and the Great Plains Program--relate closely to the ESCS research discussed in this staff paper. While the IRT report was issued independently of and does not refer to the ESCS study, it provides some useful checkpoints and data for updating and refining ESCS information on conservation expenditures in the agricultural sector.

PART II: NATURAL RESOURCE CAPITAL: HISTORICAL DATA, 1900-1975

General Guide to the Statistics

Guidelines for developing and summarizing the information contained in the 17 statistical tables are given first. Additional definitions, terms and evaluation methods specific to irrigation, drainage and conservation topics are given in the Interpretive Comments following table 17. While referenced to individual tables and data series, those comments are not intended to be only brief footnotes. Some are brief but others are quite long, depending on the item being explained.

Standard Pricing

Except where noted differently, capital values are in prices or unit costs prevailing as of the year 1972. A standard price base permits investments for different types of improvements, equipment, and facilities made at different times to be expressed in a common and additive quantity.

The particular year 1972 is used so that the estimates for natural resource capital made in this study can easily be compared and merged with other data on stocks of capital, such as those developed by the Departments of Agriculture and Commerce in their ongoing studies of farm income and wealth. There is also statistical consistence with the national income and product accounts for the United States. Since January 1976, for example, the Bureau of Economic Analysis in the Department of Commerce has shifted and revamped its historical and future constant-dollar NIPA estimates to the year 1972 as a new valuation base.

Addenda for 1975

For timeliness and to aid related studies, asset values for the year 1975 as the latest year of complete record are reconverted from 1972 dollars to 1975 dollars, using appropriate deflators shown in the last line of most tables. If desired, an entire series can be changed to constant 1975 dollars by multiplying each member of the series by its respective 1975/72 deflator first divided by 100. Arithmetic relations within each set of data still apply. Totals in 1975 dollars can be obtained either by direct conversion or by adding converted details.

Decade and Mid-Decade Figures

Capital stocks, investment rates and related data are generally recorded in the tables by 5-year intervals, starting with 1900 and ending with 1975. Annual estimates for some items are available in the sources cited. In dealing with information available only for certain years and periods not necessarily coinciding with the end or middle of decades, like different Census material collected at regular but different intervals, the approach was to synthesize an annual series, by noting trends in a partial series and interpolating for the 'missing' years. The synthetic annual series was then collapsed to show only the decade and mid-decade figures. This procedure was essential for deriving consistent capital stock and investment data on

nonfederal project irrigation facilities, all project drainage works, and farmer-owner irrigation equipment.

Units of Measure

Great precision is neither possible nor essential in analyzing capital growth in an entire economic sector like U.S. agriculture. Consequently, in dealing with large aggregates for natural resource capital in conjunction with other types of farm capital, estimates of net and gross value are given in billions of dollars rounded to the nearest $100 million. The more detailed and specific natural resource capital estimates are either in millions of dollars or in billions of dollars, rounded in either case to the nearest $5 million.

Most acreages are in millions rounded to the nearest 5 thousand acres. Areas for a few items are to the nearest 1,000 acres. Per-acre averages are rounded either to the nearest $5, $1, or $0.10, depending on the item. If it is desired to employ such averages for more rigorous statistical purposes, nearly all can be recomputed from the basic data given. Finally, while an effort has been made to choose units so that totals are the exact sum of their respective parts, some minor rounding discrepancies may remain.

Arrangement of Information

To simplify comparisons within and among topics the statistical information is arranged in a parallel format where possible, first showing aggregate figures and then their composition. This arrangement is much easier for analytical and comparison purposes than showing details first and then adding them up. Table 1 is viewed best as a recapitulation of all capital stocks in agriculture. It also shows how different forms of capital are interrelated, how estimates on particular categories can sometimes be derived by removing unwanted items from known aggregates, and how newly identified categories can themselves be used to form meaningful new aggregates. Table 2 summarizes the composition of farm capital in relative (percentage) terms after expressing total physical capital on an average per-farm basis. The percentages apply to national aggregates as well as to per-farm averages.

Beginning with table 3, particular types of natural resource capital are shown first as totals and then divided into Federal versus nonfederal components as the principal identifiable modes of financing. This highlights the important role of public finance in this aspect of U.S. economic development. Optional breakdowns are by the primary purpose of the investment (irrigation, drainage, farm conservation); the type or location of facilities (on-farm versus project improvements), and the particular legislative programs under which private investment activities have been encouraged and Federal participation authorized.

In parts of the discussion and in many tables the terms 'net investment(s)' and 'net capital stock(s)' are used interchangeably, since a number of early reviewers suggested that the latter term is harder for the average reader to follow. However, annual investment rates are always indicated as such.

Major Information Sources

Since the tables herein may be reproduced alone and included in other briefer reports without notes, principal sources of information are given in the table most general to a subject. These and additional sources may also be given in the Interpretive Comments following table 17, especially where questions of choice, availability and combined use were involved in developing acceptable acreage, investment, and capital stock estimates. Actually, many more publications were consulted to one degree or another in preparing this information. Accordingly, an extensive and specialized reference list useful in studying natural resource capital growth is included as Part III of this ESCS staff paper.

Historical Tables, 1900-1975

Table 1. Growth of total and fixed stocks of land and other physical capital in U.S. agriculture, including natural resource capital, 1900-1975

Year	Land and other physical capital 1/	Less: Land/inventories: Est. net value of land 2/	Livestock and crop inventories 3/	Equals: Total fixed capital	Net values by types of fixed capital: Residential structures	Non-residential farm structures	Producers' durable equipment 4/	Natural resource capital 5/
	Net value of land and physical capital, billions of 1972 dollars							
1900	184.0	146.1	18.2	19.7	10.4	5.4	3.0	0.9
1905	196.6	144.3	18.7	33.6	18.2	9.6	4.3	1.5
1910	210.5	145.7	19.1	45.7	24.1	12.6	6.0	3.0
1915	219.4	143.2	20.3	55.9	28.8	15.1	7.7	4.3
1920	230.2	140.7	21.7	67.8	34.8	18.3	9.7	5.0
1925	234.9	148.3	22.0	64.6	33.5	17.6	8.1	5.4
1930	240.5	154.1	21.7	64.7	32.7	16.2	9.8	6.0
1935	233.1	154.2	22.7	56.2	29.9	12.8	7.4	6.1
1940	240.2	156.6	24.8	58.8	28.5	10.9	9.4	10.0
1945	246.1	155.2	27.9	63.0	27.1	9.8	11.1	15.0
1950	272.6	160.9	27.7	84.0	28.8	14.8	21.4	19.0
1955	287.3	164.7	31.6	91.0	28.0	18.1	24.1	20.8
1960	290.8	166.6	32.7	91.5	26.4	20.6	22.2	22.3
1965	300.2	166.4	36.2	97.6	25.1	23.6	24.3	24.6
1970	311.1	166.7	37.7	106.7	23.9	26.5	29.7	26.6
1975	325.6	172.1	42.6	110.9	21.9	29.0	32.5	27.5
Addenda		Net values in 1975, in billions of 1975 dollars						
1975	470.7	255.4	63.3	152.0	29.3	41.0	44.6	37.1
	Implicit price deflators or 1975/72 cost ratios (1972=100)							
1975	144.6	148.4	148.6	137.1	133.6	141.6	137.4	135.2

PRIMARY SOURCES: Alvin S. Tostlebe, The Growth of Physical Capital in Agriculture, 1870-1950, Nat. Bur. Econ. Res. Occasional Paper 44, 1954.

John C. Musgrave. "Fixed nonresidential business and residential capital in the United States, 1925-1975." Survey of Current Business 56(4): 46-52, April 1976.

Economic Research Service, U.S. Department of Agriculture: (1) "Balance Sheet of the Farming Sector, 1975." USDA Agr. Info. Bul. No. 389, September 1975; also "Balance Sheets. . ." for prior years. (2) "Changes in Farm Production Efficiency: A Special Issue Featuring Historical Series", USDA Stat. Bul. No. 561, September 1976. (3) "Farm Income Statistics." USDA Stat. Bul. 557, July 1976.

U.S. Bureau of the Census. 1975. Historical Statistics of the United States, Colonial Times to 1970: Bicentennial edition. Pts. 1 and 2, 1200 pp.

1/, 2/, . . . See the interpretive comments following table 17.

Table 2. Changing composition of total and fixed stocks of physical capital in U.S. agriculture, including natural resource capital, 1900-1975

Year	Land and other physical capital 6/	Less: Land/inventories: Est. net value of land	Livestock and crop inventories	Equals: Total fixed capital	Composition by types of fixed capital: Residential structures	Non-residential structures	Producers' durable equipment	Natural resource capital
	$/farm	Percent of all physical capital 7/			Percent composition of fixed capital 7/			
1900	32,100	79.4	9.9	10.7	52.8	27.4	15.4	4.4
1905	32,500	73.4	9.5	17.1	54.2	28.6	12.6	4.6
1910	33,100	69.2	9.1	21.7	52.7	27.6	13.1	6.6
1915	34,300	65.2	9.3	25.5	51.5	27.0	12.5	9.0
1920	35,700	61.1	9.4	29.5	51.3	27.0	14.3	7.4
1925	36,900	63.1	9.4	27.5	51.9	27.2	12.5	8.4
1930	38,250	64.1	9.0	26.9	50.5	25.0	15.1	9.4
1935	34,200	66.2	9.7	24.1	53.2	22.8	13.1	10.9
1940	39,400	65.2	10.3	24.5	48.5	18.5	16.0	17.0
1945	42,000	63.1	11.3	25.6	43.0	15.6	17.6	23.8
1950	50,650	59.0	10.2	30.8	34.3	17.6	25.5	22.6
1955	62,950	57.3	11.0	31.7	30.7	19.9	26.5	22.9
1960	73,400	57.3	11.2	31.5	28.8	22.5	24.3	24.4
1965	89,450	55.4	12.1	32.5	25.7	24.2	24.9	25.2
1970	105,000	53.6	12.1	34.3	22.4	24.8	27.9	24.9
1975	116,000	52.8	13.1	34.1	19.7	26.1	29.5	24.7
Addenda		Averages or percentages per farm converted to 1975 dollars						
1975	167,600	54.3	13.4	32.3	19.3	27.0	29.3	24.4

PRIMARY SOURCES: See table 1.

Table 3. Natural resource capital investments in U.S. agriculture, by source of financing and type of facilities, 1900-1975

Year	All natural resource investments 8/	By source of financing: Net Federal investment	By source of financing: Private or nonfederal investment	By purpose or type of facilities: Agricultural irrigation facilities	By purpose or type of facilities: Agricultural drainage facilities	By purpose or type of facilities: Soil and watershed conservation	Total number of U.S. farms 9/
	Net value of capital investments, billions of 1972 dollars						Mil. farms
1900	0.880	--	0.880	0.330	0.550	--	5.737
1905	1.530	0.075	1.455	.650	.880	--	6.047
1910	3.030	.340	2.690	1.300	1.730	--	6.361
1915	4.310	.760	3.550	1.890	2.420	--	6.404
1920	5.010	.910	4.100	2.130	2.880	--	6.447
1925	5.410	1.005	4.405	2.040	3.370	--	6.371
1930	6.060	1.115	4.945	2.120	3.940	--	6.288
1935	6.130	1.310	4.820	2.260	3.870	--	6.812
1940	9.990	3.335	6.655	3.220	3.770	3.000	6.096
1945	15.040	5.945	9.095	4.010	3.890	7.140	5.859
1950	18.965	7.845	11.120	5.035	4.470	9.460	5.382
1955	20.800	8.895	11.905	6.170	4.730	9.900	4.565
1960	22.315	9.755	12.560	7.345	5.090	9.880	3.962
1965	24.550	11.010	13.540	9.080	5.430	10.040	3.356
1970	26.570	12.140	14.430	10.640	5.570	10.360	2.964
1975	27.465	12.280	15.185	12.265	5.500	9.700	2.808
Addenda		Net values in 1975, in billions of 1975 dollars					Mil. farms
1975	37.130	16.960	20.170	16.915	6.925	13.290	2.808
	Implicit price deflators or 1975/72 cost ratios (1972=100)						
1975	135.2	138.2	133.0	137.9	125.9	137.0	--

PRIMARY SOURCES: Various quinquennial Censuses of Agriculture and decennial Censuses of Irrigation and Censuses of Drainage, 1930 to 1974.

Bureau of Reclamation, U.S. Department of the Interior: Annual reports of the Commissioner of Reclamation (and statistical appendices thereto); also special allocation data and cost index reports supplied by the Bureau's Economics and Program Analysis Branch, Washington, D.C.

U.S. Department of Agriculture: Various reports and data provided by the Agricultural Stabilization and Conservation Service, the Economic Research Service, the Soil Conservation Service and the Statistical Reporting Service. Also, selected issues of the USDA annual periodical Agricultural Statistics, mainly for 1952, 1957, 1962, 1967, 1972, 1974, 1975, and 1976.

Table 4. Natural resource investments per farm and per acre, by purpose and different measures of productive land, United States, 1900-1975

Year	Resource investments per farm 10/	Composition by types of investments: Agricultural irrigation facilities	Agricultural drainage facilities	Soil and watershed conservation	Natural resource investments per acre: All farm cropland in crops or fallow	All farm cropland and pasture	All land used for agriculture
	$/farm	Percent composition by types 11/			1972 dollars per acre 12/		
1900	150	37.5	62.5	--	2.80	1.30	0.70
1905	250	42.5	57.5	--	4.75	2.25	1.10
1910	475	42.9	57.1	--	9.20	4.30	2.20
1915	675	43.9	56.1	--	12.40	5.80	3.00
1920	775	42.5	57.5	--	13.60	6.45	3.50
1925	850	37.7	62.3	--	14.60	7.00	3.80
1930	965	35.0	65.0	--	15.90	7.20	4.20
1935	900	36.9	63.1	--	16.30	6.85	4.30
1940	1,640	32.3	37.7	30.0	27.10	10.80	7.00
1945	2,570	26.7	25.9	47.4	40.40	15.00	10.50
1950	3,530	26.5	23.5	50.0	50.30	18.90	13.50
1955	4,560	29.7	22.7	47.6	55.00	20.50	15.30
1960	5,630	32.9	22.8	44.3	62.90	22.80	17.20
1965	7,320	37.0	22.1	40.9	73.10	25.50	19.60
1970	8,960	40.0	21.0	39.0	80.00	28.20	21.60
1975	9,780	44.7	20.0	35.3	75.00	28.60	22.10
Addenda		Average and percentages in 1975 dollars			1975 dollars per acre		
1975	13,220	45.5	18.7	35.8	100.00	40.00	30.00
		Price deflators or 1975/72 cost ratios			General ratio (1972=100)		
1975	135.2	137.9	125.9	137.0	135.2	135.2	135.2

PRIMARY SOURCES: See table 3.

Table 5. Capital investments in agricultural irrigation, by source of financing and type of facilities, United States, 1900-1975

Year	All agricultural irrigation facilities 13/	By source of financing: Net Federal investment 14/	By source of financing: Private or nonfederal investment 15/	Off-farm or project facilities: Bureau of Reclamation facilities	Off-farm or project facilities: Other group facilities	Off-farm or project facilities: All project facilities	All on-farm or individual facilities 16/
	Net value of facilities, billions of 1972 dollars						
1900	0.330	--	0.330	--	0.300	0.300	0.030
1905	.650	0.080	.570	0.080	.530	.610	.040
1910	1.300	.340	.960	.340	.770	1.110	.190
1915	1.890	.750	1.140	.750	.900	1.650	.240
1920	2.130	.900	1.230	.900	.960	1.860	.270
1925	2.040	1.030	1.010	1.030	.930	1.960	.080
1930	2.120	1.140	.980	1.140	.890	2.030	.090
1935	2.260	1.350	.910	1.350	.830	2.180	.080
1940	3.220	1.870	1.350	1.870	1.100	2.970	.250
1945	4.010	2.340	1.670	2.330	1.270	3.600	.410
1950	5.035	3.020	2.015	3.000	1.320	4.320	.715
1955	6.170	3.760	2.410	3.720	1.390	5.110	1.060
1960	7.345	4.465	2.880	4.385	1.485	5.870	1.475
1965	9.080	5.330	3.750	5.165	1.805	6.970	2.110
1970	10.640	5.990	4.650	5.800	2.160	7.960	2.680
1975	12.265	6.440	5.825	6.410	2.370	8.780	3.485
Addenda		Net values in 1975, in billions of 1975 dollars					
1975	16.915	9.005	7.910	8.960	3.315	12.275	4.640
	Implicit price deflators or 1975/72 cost ratios (1972=100)						
1975	137.9	139.8	135.7	139.8	139.8	139.8	133.1

PRIMARY SOURCES: U.S. Bureau of the Census: Census of Agriculture, 1969. Volume IV, Irrigation; also chapter 9 in Volume II on "Irrigation and Drainage on Farms." The major statistical checkpoint for project irrigation facilities and investment, especially for projects not constructed or operated by the Bureau of Reclamation, was the report Irrigation of Agricultural Lands , Volume III of the 1959 Census of Agriculture. All Censuses from 1930 on were consulted.

Bureau of Reclamation, U.S. Department of the Interior: Water and Land Resource Accomplishments 1975: Summary Report , and Statistical Appendix 2 thereto on "Finances and Physical Features." These constitute official reports to Congress by the Commissioner of Reclamation. Equivalent annual and statistical reports of the Commissioner from 1961 on were also consulted.

U.S. Department of Agriculture. Agricultural Statistics and other agency materials dealing with on-farm irrigation facilities and cost-sharing. Agencies given under tables 1 and 13.

"1976 Irrigation Survey." The Irrigation Journal 26(6): 23-30, November/December 1976; also selected prior Survey and Directory issues of the same Journal.

Table 6. Irrigated acreage and capital investment per acre, by type of facilities, United States, 1900-1975

Year	Net farm acreage irrigated	Acreages served, by types of facilities: Bureau of Reclamation facilities	Other project facilities	On-farm facilities only	Average investment per acre irrigated: Investment in project facilities	Investment in on-farm facilities	Investment in all facilities
	Millions of acres 17/				Net per acre, in 1972 dollars 18/		
1900	7.700	--	7.300	0.400	40	5	45
1905	8.640	0.020	8.140	.480	70	5	75
1910	10.000	.475	8.980	.545	110	20	130
1915	11.195	.860	9.555	.780	150	20	170
1920	13.350	2.205	10.135	1.010	140	20	160
1925	13.815	2.340	10.235	1.240	145	5	150
1930	14.600	2.790	10.340	1.470	140	5	145
1935	13.000	2.935	8.845	1.220	170	5	175
1940	18.120	3.390	12.985	1.745	165	15	180
1945	20.665	4.160	11.085	5.420	175	20	195
1950	25.905	5.080	9.900	10.925	165	30	195
1955	30.275	6.260	10.860	13.155	170	35	205
1960	33.940	6.900	10.980	16.060	175	40	215
1965	37.470	8.010	11.410	18.050	185	55	240
1970	41.630	8.570	12.295	20.763	190	65	255
1975	45.305	9.310	13.270	22.725	195	75	270
Addenda:		Millions of acres			Net per acre, in 1975 dollars		
1975	45.305	9.310	13.270	22.725	270	105	375

PRIMARY SOURCES: See table 5.

Table 7. Irrigation related to hydropower, flood control, general water supply and other multi-purposes of Bureau of Reclamation projects, United States, 1903-1975

Year	Cumulative construction appropriations ($ current)	Gross real investment: All Bureau facilities	Gross real investment: Non-irrigation facilities	Irrigation facilities: Gross real investment	Irrigation facilities: Net capital value	Bureau project acreages: Irrigable project acreage	Bureau project acreages: Net acreage irrigated
	19/	20/	20/	21/	22/	23/	24/
	$Billions	Billions of 1972 dollars				Millions of acres	
1903	--	--	--	--	--	--	--
1905	0.028	0.080	--	0.080	0.080	0.039	0.022
1910	.069	.349	.009	.340	.340	.917	.473
1915	.122	.798	.048	.750	.750	1.472	.857
1920	.166	.950	.050	.900	.900	2.845	2.205
1925	.218	1.100	.070	1.030	1.030	3.143	2.339
1930	.274	1.245	.105	1.140	1.140	3.634	2.790
1935	.481	1.760	.410	1.350	1.350	3.614	2.935
1940	.747	2.870	1.000	1.870	1.870	4.180	3.391
1945	1.049	3.710	1.380	2.330	2.330	5.030	4.162
1950	1.921	5.240	2.235	3.005	3.000	6.025	5.077
1955	2.763	6.850	3.110	3.740	3.720	7.368	6.261
1960	3.608	8.125	3.705	4.420	4.385	8.171	6.900
1965	4.817	10.295	5.080	5.215	5.165	9.612	8.012
1970	5.898	11.815	5.940	5.875	5.800	10.198	8.570
1975	7.448	13.175	6.665	6.510	6.410	11.212	9.530
Addenda	Values in 1975, in billions of 1975 dollars						
1975	--	18.195	9.095	9.100	8.960	--	--
	Implicit price deflators or 1975/72 cost ratios (1972=100)						
1975	--	138.1	136.4	139.8	139.8	--	--

PRIMARY SOURCES: Bureau of Reclamation, U.S. Department of the Interior, as detailed under table 5. Particular materials and their use in developing these estimates are described more fully in comments 19 to 22 following table 17.

Table 8. Aggregate and per-acre investments in farmer-owned irrigation facilities and equipment, by water application methods, United States, 1900-1975

Year	All on-farm or individual facilities 25/	By irrigation methods: Gravity irrigation facilities 26/	By irrigation methods: Sprinkler irrigation facilities 27/ 30/	Acres by methods: Gravity irrigation acreage	Acres by methods: Sprinkler irrigation acreage	On-farm investments per acre: Gravity irrigation methods	On-farm investments per acre: Sprinkler irrigation methods
	Net investment, $Bil. (1972 dol.)			Millions of acres		1972 dollars per acre 28/	
1900	0.030	0.030	--	7.700	--	5	--
1905	.040	.040	--	8.640	--	5	--
1910	.190	.190	--	10.000	--	20	--
1915	.240	.240	--	11.195	--	20	--
1920	.270	.270	--	13.350	--	20	--
1925	.080	.080	--	13.815	--	5	--
1930	.090	.090	--	14.600	--	5	--
1935	.080	.080	--	13.000	--	5	--
1940	.250	.130	0.120	17.850	0.270	7	450
1945	.410	.210	.200	20.250	.415	10	455
1950	.715	.350	.365	24.915	.990	15	370
1955	1.060	.510	.550	28.005	2.270	20	245
1960	1.475	.800	.675	30.500	3.440	25	195
1965	2.110	1.070	1.040	31.940	5.530	35	190
1970	2.680	1.180	1.500	33.805	7.825	35	195
1975	3.485	.980	2.505	33.205	12.100	30	210
Addenda:	Billions of 1975 dollars			Millions of acres		1975 dollars per acre	
1975	4.640	1.345	3.295	33.205	12.100	40	275
1975/72 index	133.1	137.0	131.6	--	--	--	--

PRIMARY SOURCES: See tables 5 and 7.

Table 9. Gross capital stocks and net investments in farmer-owned sprinkler irrigation facilities and equipment, United States, 1940-1975

Year	Gross stocks and net investment, in millions of 1972 dollars	Total for sprinkler irrigation facilities	Water supply components: Wells or other water sources	Water supply components: Pumps and power units	Subtotal, water supply components	Subtotal, sprinkler distribution systems
	29/	30/				
1940	Gross stocks, $mil.	190	10	10	20	170
	Net investment, $mil.	120	5	5	10	110
	Percent of net	100	50.0	50.0	8.7	91.7
1945	Gross stocks, $mil.	285	15	15	30	255
	Net investment, $mil.	200	10	10	20	170
	Percent of net	100	50.0	50.0	15.0	85.0
1950	Gross stocks, $mil.	470	35	40	75	395
	Net investment, $mil.	365	25	30	55	310
	Percent of net	100	45.5	54.5	15.1	84.9
1955	Gross stocks, $mil.	785	90	105	195	590
	Net investment, $mil.	550	70	80	150	400
	Percent of net	100	46.7	53.3	27.3	72.7
1960	Gross stocks, $mil.	1,120	155	180	335	785
	Net investment, $mil.	675	95	110	205	470
	Percent of net	100	46.3	53.7	30.4	69.6
1965	Gross stocks, $mil.	1,720	265	330	595	1,125
	Net investment, $mil.	1,040	160	200	360	680
	Percent of net	100	44.4	55.6	34.6	65.4
1970	Gross stocks, $mil.	2,475	405	530	935	1,540
	Net investment, $mil.	1,500	225	295	520	980
	Percent of net	100	43.3	56.7	34.7	65.3
1975	Gross stocks, $mil.	3,950	700	905	1,605	2,345
	Net investment, $mil.	2,505	415	535	950	1,555
	Percent of net	100	43.7	56.3	37.9	62.1

PRIMARY SOURCES: Various quinquennial Censuses of Agriculture from 1949 to 1974 and decennial Censuses of Irrigation from 1949 to 1969. Also the Irrigation Journal and its annual irrigation surveys since 1956, as cited under table 5.

Table 10. Acreages irrigated, gross capital stocks and net investments in farmer-owned sprinkler equipment, by changing sprinkler technologies, United States, 1940-1975

Year	Items (acres, 1972 dollars)	Total for sprinkler distribution system 27/, 30/	By major types of sprinkler system: Permanent or solid-set systems 31/	Portable hand-move systems 32/	Mobile other than center pivots 33/	Self-propelled center-pivot systems 34/
		Amount	Percent of total			
1940	Area irrigated, mil. ac.	0.270	100.0	--	--	--
	Gross stocks, $mil.	170	100.0	--	--	--
	Net investment, $mil.	110	100.0	--	--	--
1945	Area irrigated, mil. ac.	0.415	100.0	--	--	--
	Gross stocks, $mil.	225	100.0	--	--	--
	Net investment, $mil.	170	100.0	--	--	--
1950	Area irrigated, mil. ac.	0.990	55.6	44.4	--	--
	Gross stocks, $mil.	395	86.1	13.9	--	--
	Net investment, $mil.	310	85.5	14.5	--	--
1955	Area irrigated, mil. ac.	2.270	28.4	61.3	10.3	--
	Gross stocks, $mil.	590	67.8	27.1	5.1	--
	Net investment, $mil.	400	69.6	24.9	5.5	--
1960	Area irrigated, mil. ac.	3.440	21.9	66.2	11.0	--
	Gross stocks, $mil.	785	59.8	33.8	6.4	--
	Net investment, $mil.	470	62.7	30.9	6.4	--
1965	Area irrigated, mil. ac.	5.530	16.0	63.0	13.0	8.0
	Gross stocks, $mil.	1,125	48.9	37.8	8.4	4.9
	Net investment, $mil.	680	51.6	33.8	8.0	6.6
1970	Area irrigated, mil. ac.	7.825	14.0	51.2	18.6	16.2
	Gross stocks, $mil.	1,540	44.1	31.5	12.7	11.7
	Net investment, $mil.	980	46.9	26.5	12.3	14.3
1975	Area irrigated, mil. ac.	12.100	11.4	32.3	24.4	30.3
35/	Gross stocks, $mil.	2,345	36.1	16.2	17.9	26.7
	Net investment, $mil.	1,555	37.0	13.2	16.4	29.9

PRIMARY SOURCES: See table 5 and 9.

Table 11. Capital investments in farmland development drainage, by source of financing and type of facilities, United States, 1900-1975

Year	All farmland drainage facilities	By source of financing: Net Federal investment	By source of financing: Private or nonfederal investment	By type of facilities: On-farm drainage facilities	By type of facilities: Project or group facilities	Net farmland development drainage 43/	Net investment per acre drained 40/
	Net value of facilities, $Bils. (1972 dols.) 42/					Mil. ac.	$/ac.
1900	0.550	--	0.550	0.025	0.525	6.265	90
1905	.880	--	.880	.040	.840	11.620	75
1910	1.730	--	1.730	.085	1.645	22.190	80
1915	2.420	--	2.420	.130	2.290	34.830	70
1920	2.880	--	2.880	.180	2.700	49.140	60
1925	3.370	--	3.370	.200	3.170	56.810	60
1930	3.940	--	3.940	.215	3.725	62.505	65
1935	3.870	--	3.870	.205	3.665	64.450	60
1940	3.770	0.015	3.755	.210	3.560	67.880	55
1945	3.890	.035	3.855	.405	3.485	68.380	57
1950	4.470	.140	4.330	.940	3.530	73.850	60
1955	4.730	.215	4.515	1.180	3.550	76.805	62
1960	5.090	.325	4.765	1.500	3.590	79.110	64
1965	5.430	.430	5.000	1.770	3.660	80.135	68
1970	5.570	.470	5.100	1.855	3.715	81.155	69
1975	5.500	.440	5.060	1.760	3.740	81.970	67
Addenda:	Net values in billions of 1975 dollars					Mil. ac.	$/ac.
1975	6.925	.555	6.370	2.215	4.710	81.970	84
	Implicit deflators or 1975/72 cost ratios (1972=100)						
1975	125.9	126.1	125.9	125.9	125.9	--	125.9

PRIMARY SOURCES: See table 11.

Table 12. Drained acreages and facilities investment per acre, by purpose of drainage, United States, 1900-1975

Year	Net agricultural area drained	By purpose of drainage: Farmland development drainage	By purpose of drainage: Irrigation-associated drainage	Net investment in irrigation drainage	Facilities investment per acre: All agricultural drainage	Facilities investment per acre: Farmland development drainage	Facilities investment per acre: Irrigation-associated drainage
	36/	37/		38/	39/	40/	41/
	Millions of acres			$ Millions (1972 dol.)	Net per acre, in 1972 dollars		
1900	6.295	6.265	0.030	35	92	90	--
1905	11.675	11.620	.055	50	80	75	--
1910	22.295	22.190	.105	90	82	80	--
1915	35.020	34.830	.190	150	73	70	--
1920	49.385	49.140	.245	186	62	60	760
1925	57.825	56.810	1.015	204	62	60	200
1930	63.900	62.505	1.395	317	67	65	225
1935	66.300	64.450	1.850	315	63	60	170
1940	70.070	67.880	2.190	313	58	55	145
1945	70.415	68.380	2.035	307	60	57	150
1950	76.020	73.850	2.170	310	63	60	145
1955	79.165	76.805	2.360	340	64	62	145
1960	81.670	79.110	2.560	344	67	64	135
1965	82.895	80.135	2.760	347	70	68	125
1970	84.125	81.155	2.970	352	70	69	120
1975	85.265	81.970	3.295	351	69	67	110
Addenda:	Millions of acres			$ Millions (1975 dol.)	Net per acre, in 1975 dollars		
1975	85.265	81.970	3.295	470	86	84	148

PRIMARY SOURCES: U.S. Bureau of the Census: Census of Agriculture, 1969. Volume VI, Drainage of Agricultural Lands, also chapter 9 in Volume II on "Irrigation and Drainage on Farms." Major checkpoints for project drainage investments going back to before 1870 were the 1940 U.S. Census reports "Drainage of Agricultural Lands: United States Summary" and "Drainage of Alluvial Lands", both published in 1943.

U.S. Department of Agriculture: Agricultural Statistics and other agency materials dealing with on-farm drainage improvements and group drainage facilities and organizations. Agencies given under tables 1 and 13.

Irrigation-associated drainage: Information variously from Censuses of Irrigation and Drainage, Agricultural Statistics and other sources.

Table 13. Capital investments in soil conservation and watershed land protection, by source of financing and program, United States, 1935-1975

Year	All permanent conservation measures 44/	By source of financing: Net Federal investment 45/	By source of financing: Private or nonfederal investment 45/	By type of program or authority 44/: Rural Environmental Assistance	By type of program or authority 44/: Great Plains Program	By type of program or authority 44/: Watershed land protection	Watershed protection as share of total
	Net value of existing measures, billions of 1972 dollars						Percent
1935	--	--	--	--	--	--	--
1940	3.000	1.500	1.500	3.000	--	--	--
1945	7.140	3.570	3.570	7.140	--	--	--
1950	9.460	4.730	4.730	9.460	--	--	--
1955	9.900	4.950	4.950	9.900	--	--	--
1960	9.880	4.965	4.915	9.515	0.015	0.350	3.5
1965	10.040	5.250	4.790	9.050	.060	.930	9.3
1970	10.360	5.680	4.680	8.535	.115	1.710	16.5
1971	10.230	5.650	4.580	8.305	.125	1.800	17.6
1972	10.100	5.590	4.510	8.150	.130	1.820	18.0
1973	9.960	5.525	4.435	8.010	.130	1.820	18.3
1974	9.830	5.450	4.380	7.875	.135	1.820	18.5
1975	9.700	5.400	4.300	7.745	.135	1.820	18.8
Addenda:	Net values in 1975, billions of 1975 dollars						Percent
1975	13.290	7.400	5.890	10.595	.185	2.500	18.8
	Implicit price deflators or 1975/72 cost ratios (1972=100)						
1975	137.0	137.0	137.0	136.8	137.0	137.4	--

PRIMARY SOURCES: U.S. Department of Agriculture agencies as noted for each program.

Rural Environmental Assistance Program: Program Analysis Branch, Agricultural Stabilization and Conservation Service. Data on annual cost-sharing assistance 1936-1975 for permanent soil and water conservation measures, irrigation measures, and drainage measures.

Great Plains Program: Resource Development Division, Soil Conservation Service. Data on annual cost-sharing assistance 1957-75 for permanent soil and water conservation measures and irrigation measures. Also the report "Economic Evaluation of the Great Plains Program" by James Kasal and W.B. Back. Economic Research Service Rpt. 440, July 1970, for definitions and cost sharing information.

Watershed protection measures: Natural Resource Economics Division, Economic Research Service. "Inventory of Benefits, Costs and Other Data for P.L. 566 Watershed Work Plans", compiled annually since 1958 for the Soil Conservation Service. The watershed protection measures considered herein are limited to structural measures for land protection per se. Also see comment 44 following table 17 for additional explanations and qualifications.

Table 14. Average annual net capital investment in natural resources in agriculture, by source of financing and type of facilities, United States, 1900-1975

Years	All natural resource investments 46/	By source of financing: Net Federal investment 46/	By source of financing: Private or nonfederal investment	Investment by purpose or type of facilities: Agricultural irrigation facilities	Agricultural drainage facilities	Soil and water conservation 47/	Watershed protection measures 47/
	Average net investment per year, millions of 1972 dollars						
1901-05	130	15	115	65	65	--	--
1906-10	300	80	220	130	170	--	--
1911-15	260	90	170	120	140	--	--
1916-20	140	30	110	50	90	--	--
1921-25	80	15	65	-20	100	--	--
1926-30	130	20	110	15	115	--	--
1931-35	15	40	-25	30	-15	--	--
1936-40	770	405	365	190	-20	600	--
1941-45	1,010	520	490	155	25	830	--
1946-50	785	380	405	205	115	465	--
1951-55	370	210	160	230	50	90	--
1956-60	305	170	135	240	70	-75	70
1961-65	445	250	195	345	70	-85	115
1966-70	405	225	180	305	30	-90	160
1971-75	180	30	150	325	-15	-155	25
Addenda	Average net investment per year, millions of 1975 dollars 48/						
1971-75	240	40	200	440	-20	-210	30

PRIMARY SOURCES: See table 13.

Table 15. Average annual net capital investment in natural resources versus other types of fixed agricultural capital, United States, 1900-1975

Years	All fixed capital investment 49/	By source of financing: Net Federal investment	By source of financing: Private or nonfederal investment	Net investment rates by capital components: Residential farm structures	Net investment rates by capital components: Non-residential structures	Net investment rates by capital components: Producers' durable equipment	Net investment rates by capital components: Natural resource investments
	Average net investment per year, millions of 1972 dollars						
1901-05	2,790	15	2,775	1,560	840	260	130
1906-10	2,420	80	2,340	1,180	600	340	300
1911-15	2,040	90	1,950	940	500	340	260
1916-20	2,380	30	2,350	1,200	640	400	140
1921-25	-615	15	-630	-260	-140	-320	105
1926-30	30	20	10	-160	-280	340	130
1931-35	-1,705	40	-1,745	-560	-680	-480	15
1936-40	510	405	105	-280	-380	400	770
1941-45	855	520	335	-280	-220	345	1,010
1946-50	4,180	380	3,800	340	1,000	2,055	785
1951-55	1,380	210	1,170	-160	660	510	370
1956-60	145	170	-25	-320	500	-340	305
1961-65	1,195	250	945	-260	600	410	445
1966-70	1,820	225	1,595	-240	580	1,075	405
1971-75	860	29	831	-380	500	560	180
Addenda:	Average net investment per year, millions of 1975 dollars 50/						
1971-75	1,050	40	1,010	-440	595	655	240

PRIMARY SOURCES: See table 1 on sources for fixed capital information.

Table 16. Cumulative or gross natural resource investments in U.S. agriculture, by source of financing and type of facilities, 1900-1975

Year	All natural resource investments	By source of financing: Cumulative Federal investment	By source of financing: Private or nonfederal investment	By purpose or type of facilities: Agricultural irrigation facilities	By purpose or type of facilities: Agricultural drainage facilities	By purpose or type of facilities: Soil and watershed conservation	Annual gross rate for prior 5 years 52/
	Cumulative gross investment, billions of 1972 dollars 51/						$Millions
1900	1.300	--	1.300	0.520	0.780	--	--
1905	2.000	0.075	1.925	.860	1.140	--	140
1910	3.460	.340	3.120	1.410	2.050	--	290
1915	4.800	.760	4.040	2.000	2.800	--	270
1920	5.620	.910	4.710	2.280	3.340	--	165
1925	6.360	1.040	5.320	2.430	3.930	--	150
1930	7.170	1.155	6.015	2.560	4.610	--	160
1935	7.420	1.370	6.050	2.760	4.660	--	50
1940	11.990	3.560	8.430	4.040	4.680	3.270	915
1945	18.310	6.700	11.610	4.980	4.940	8.390	1,265
1950	24.390	9.630	14.760	6.210	5.700	12.480	2,950
1955	29.020	11.930	17.090	7.660	6.150	15.210	925
1960	33.920	14.410	19.510	9.280	6.760	17.880	980
1965	39.970	17.130	22.840	11.720	7.360	20.890	1,210
1970	45.860	19.670	26.190	14.250	7.800	23.810	1,180
1975	50.440	21.060	29.380	17.230	8.000	25.210	915
Addenda	Cumulative investment to 1975, in billions of 1975 dollars 53/						$Millions
1975	68.195	29.105	39.090	23.585	10.070	34.540	1,250

PRIMARY SOURCES: See table 5 (irrigation), table 11 (drainage) and table 13 (conservation).

Table 17. Population, employment, labor use and alternative measures of productive agricultural land, United States, 1900-1975

Year	Total farm population (April 1) 54/	Total family and hired employment 54/	Average annual use of farm labor 54/	Total number of reported farms 9/	Measures of productive land 12/: Planted crops and fallow 55/	Cropland and pasture in farms 55/	All land used for agriculture 56/
	Millions		Bil. hrs.	Millions	Millions of acres		
1900	29.618	12.600	21.3	5.737	314	671	1340
1905	30.823	13.100	22.0	6.047	322	689	1374
1910	32.077	13.555	22.7	6.361	330	706	1408
1915	32.440	13.592	23.4	6.404	348	742	1414
1920	31.974	13.432	24.1	6.447	368	779	1420
1925	31.190	13.036	23.9	6.371	370	773	1420
1930	30.529	12.497	22.9	6.288	382	843	1432
1935	32.161	12.733	21.0	6.812	377	893	1425
1940	30.547	10.979	20.5	6.096	368	924	1423
1945	24.420	10.000	18.8	5.859	372	1003	1435
1950	23.048	9.926	15.1	5.382	377	1005	1407
1955	19.078	8.381	12.8	4.565	378	1017	1363
1960	15.635	7.057	9.8	3.962	355	980	1294
1965	12.363	5.610	7.3	3.356	336	962	1254
1970	9.712	4.523	6.0	2.954	332	943	1230
1975	8.864	4.357	5.3	2.808	367	959	1241

PRIMARY SOURCES: Farm population, employment and labor: Economic Research Service, U.S. Department of Agriculture, as published annually in Agricultural Statistics and in the Economic Report of the President together with the Annual Report of the Council of Economic Advisors (published each January).

Number of farms: Statistical Reporting Service, U.S. Department of Agriculture, as published annually in Agricultural Statistics, in the USDA Statistical Bulletin series and in SRS monthly releases.

Productive land measures: Estimates are from various sources but primarily from Economic Research Service publications as based on Bureau of Census, SRS and other agency data on land use in the United States. See especially H. Thomas Frey, "Major Uses of Land in the United States: Summary for 1969." USDA Agr. Econ. Rpt. No. 247, December 1973; also H. Thomas Frey and Robert C. Otte, "Cropland for Today and Tomorrow." USDA Ag. Econ. Rpt. No. 291, July 1975; also Kathryn A. Zeimetz, Elizabeth Dillon, Ernest E. Hardy and Robert C. Otte, "Dynamics of Land Use in Fast Growth Areas." USDA Agr. Econ. Rpt. No. 325, April 1976.

Interpretive Comments on Tables

(Numbers may not be in exact order in the tables)

1/ In this study physical agricultural capital is considered to include all land in farms, farm inventories of livestock and crops, and all types of depreciable (fixed) capital. This of course encompases farm homes, nonresidential structures, farm machinery and farm vehicles. But it also includes structures and equipment associated with conservation, irrigation and drainage activities. Because the totals in this column are inclusive of irrigation and drainage facilities not within as well as those within farms, they will exceed totals on farm physical capital published elsewhere. Durable farm household equipment and home furnishings are not included, as they are not considered to be production capital within the scope of this study.

2/ The net land values are estimated as the difference between the total value of farm real estate and the value of residential and nonresidential structures combined. The net land values are overstated to the extent that values of off-farm or project irrigation and drainage facilities are captured in farm real estate prices.

3/ The studies of Tostlebe and others show that, on a national basis since 1900, livestock have accounted for from about 60 percent (in 1955) to 80 percent (in 1935) of the real or constant-dollar value of farm business inventories. The average has been about 65 percent, with a very gradual trend toward relatively greater crop holdings.

4/ To simplify accounting and discussion, capital expenditures for and net capital values of producers' durable irrigation equipment ($2.5 billion in 1975) are arbitrarily classed under natural resource capital only, the last column of this table. Producers' durable equipment ($32.5 billion in 1975) includes all farm tractors, farm machinery, and motor vehicles, excluding a prorated use of vehicles for personal or family use.

5/ Natural resource capital includes: Depreciable improvements to land like conservation terraces and waterways; irrigation water supply and distribution facilities, as well as drainage facilities, whether or not on farms (wells, ponds, drain tile or ditches); and any durable equipment purchased for irrigation or drainage purposes (pumps, engines, motors, pipe, sprinklers, etc.).

6/ Net capital stocks per farm are in 1972 dollars. For the year 1975, averages are given both in 1972 and 1975 dollars. The averages are computed as col. 1 in table 1 divided by col. 7 in table 3, the latter being the total number of farms in the United States.

7/ Corresponding net dollar values are in table 1.

8/ Entries begin with the year 1900, but certain Census information useful for deriving investment and capital stocks for irrigation and drainage dated back to 1870. No information was available for soil conservation and land protection investments prior to 1936 but these activities were of little national significance before then.

9/ The total number of farms in the United States has been reported at least annually by the Statistical Reporting Service (now part of the Economics, Statistics, and Cooperatives Service) of the U.S. Department of Agriculture. These ESCS estimates are used herein and may differ from counts made at annual or other intervals by other agencies such as the Bureau of the Census.

10/ Natural resource investments per farm are in constant 1972 dollars. For 1975 they are also given in current 1975 dollars. Averages are computed as col. 1 of table 3 divided by col. 7 of table 3.

11/ Corresponding net dollar values are in table 3.

12/ Alternative averages per acre in table 4 are derived from table 3 and the several measures of productive land recorded in table 17. That is, averages per acre are computed by changing the totals in col. 1 of table 3 to millions of 1972 dollars, and then dividing by each of the three areal concepts of productive land given in table 17.

13/ Irrigation facilities include: (a) Land improvements made to permit or facilitate irrigation, such as farm ditches or land leveling, (b) durable equipment needed for irrigation, such as pumps, power units or sprinkler systems, and (c) any other irrigation water-supply, storage or distribution works, such as wells, ponds and reservoirs--regardless of where located and by whom financed. Financing does not necessarily imply ownership of the facilities.

Federal financing as explained further in note 14/ is separated from that by such other groups as mutual irrigation companies, irrigation districts, State agencies or individual farmers. Further, Bureau of Reclamation expenditures for project-type irrigation are separated from its other project investments. Project (off-farm) facilities likewise are separated from on-farm or farmer-owned facilities, even though the latter may have been financed in part through Federal cost-sharing programs.

14/ The net Federal investment in irrigation facilities is by and large (until about 1940 it was entirely) the net value of that portion of Bureau of Reclamation investments in project property, plant and equipment reasonably allocable to irrigation in multipurpose projects and to single-purpose irrigation projects as such. Details and comparisons of irrigation with other important authorized resource development activities of the Bureau of Reclamation are in table 7.

For years following 1936 part of the net capital value of Federal irrigation investments (a peak of 3 percent in 1970) is accounted for by Federal cost-sharing for certain approved on-farm irrigation improvements under the 'ACP' or Agricultural Conservation Program, now called the 'REAP' or Rural Environmental Assistance Program. Some limited Federal cost-sharing for irrigation has also been authorized (beginning in 1957) under the Great Plains Conservation Program.

For completeness Federal irrigation investments should also have included investments by the Bureau of Indian Affairs and the U.S. Army Corps of Engineers. However, because much less specific information was available on these minor agency programs than for the Bureau of Reclamation, which helps plan and operate many of the BIA- and CE-funded facilities anyway, estimated BIA and CE

investments are included but not specifically identified in the category 'other group facilities'.

15/ Nonfederal irrigation investments include: (a) Independent private investments in on-farm irrigation improvements and facilities from 1970 to 1975, including farmer-owned irrigation equipment; (b) additional on-farm facility and land preparation investments made between 1936 and 1975 under the REAP cost-sharing program; (c) investments in group irrigation facilities made by irrigation organizations from 1870 to 1975, excluding those facilities constructed and still owned by the Bureau of Reclamation; (d) irrigation features of structures installed since 1954 under the Watershed Protection and Flood Prevention Act; and (e) some private irrigation investments made since 1957 under cost-sharing provisions of the Great Plains Conservation Program.

16/ On-farm irrigation investments may be for land leveling or other field preparations, irrigation wells, ponds, reservoirs, stream diversion works, flumes, weirs, irrigation ditches, drops, turnouts, check dams, pumps and power units, pipes, tubes, or sprinkler irrigation equipment--that is to say, any identifiable durable feature or component of a farm irrigation system. Some Federal investment is incorporated ($320 million or 9.2 percent in 1975) via the above-described REAP and Great Plains Conservation Programs. It is limited chiefly to land preparation and certain water supply improvements.

17/ Acreages refer to net areas actually irrigated rather than possibly irrigated. They correspond definitionally with the Bureau of the Census reporting item 'irrigated land in farms'. Certain totals are adjusted from Census and other reports to provide decade or mid-decade estimates, to fill in for missing years, and to recognize observed tendencies for certain authorities to mis-report net areas irrigated. Bureau of Reclamation acreages are from various Bureau documents. The 'other project' acreages, as well as the on-farm non-project acreages, are compiled and/or adjusted from numerous Census and other sources.

18/ Averages are computed by respectively dividing data col. 1 of this table into the net values in table 5, first for all project facilities, then for all on-farm facilities and then for all irrigation facilities. This procedure segregates the overall net investment per acre of irrigated land into project facilities and equipment versus on-farm facilities and equipment. Because modern irrigation projects not only require major outlays for group storage, pumping, and diversion works, but also substantial complementary investments on farms, the per-acre averages in this table should not be used to judge between project and nonproject irrigation as alternatives for promoting irrigation development.

To explain this point more, the key to comparing project versus nonproject irrigation would be reliable information on investments in on-farm facilities, divided between farms within and outside irrigation projects. Neither the Bureau of the Census nor other agencies have collected such information. However, from (a) trends since 1900 in irrigated acres outside of projects, (b) trends since 1940 in ground versus surface water use, and (c) trends since 1940 in sprinkler versus gravity irrigation, it can be cautiously determined that, as of 1975, the net value for the United States of all on-farm and off-farm facilities associated with project irrigation was about

$420 per acre irrigated. The net value of facilities associated with nonproject irrigation was about $120 per acre. Both averages are in terms of 1972 price levels.

Similarly determined per-acre averages back in 1945 were about $255 for project irrigation and $20 for nonproject irrigation. Measured by the required net capital investment in facilities and equipment, the real unit cost of nonproject irrigation in the United States increased by about 6 percent per year from 1945-75. For project irrigation it increased by about 1.6 percent per year. By the same measure, however, project irrigation facilities in 1975 were, per acre irrigated, still about 3 times as valuable as nonproject irrigation facilities and equipment.

19/ Cumulative Bureau of Reclamation (BREC) construction appropriations are developed from annual (1903-75) Congressional appropriations for all BREC activities, less allocations to operation and maintenance, loan programs, investigations, advance planning, administration, and emergency funds. These and additional annual data on construction fund allocations to irrigation and other specific purposes of Bureau projects were supplied and explained by the Economics Branch of the Bureau in Washington, D.C.

Cumulative allocations of BREC construction funds to irrigation purposes as a percentage of construction funding for all purposes are then used to divide the estimated actual cost of in-place project plant, property and equipment between the irrigation and nonirrigation purposes of single and multipurpose projects. Actual costs (book values) for Bureau facilities by each project and major project units are updated annually in official statistical reports of the Commissioner of Reclamation.

The procedure just described presumes that facilities actually in place at a given time are related in a functional way to irrigation and other project purposes according to administrative allocations of original construction appropriations to the several purposes. Deferral of project starts, construction delays and similar lags are recognized, but over the long run are assumed to have been offsetting in their effects among the different purposes of BREC projects.

20/ The gross real Bureau of Reclamation investment in constant 1972 dollars represents the estimated cost of reproducing all existing irrigation and other project works at unit costs prevailing in 1972. The procedure for arriving at such real reproduction cost of BREC facilities will be reviewed in some detail as the same ideas were helpful in obtaining estimates for other irrigation drainage and conservation assets too:

The real BREC investment was computed by deflating yearly increases in current-dollar book values by appropriate construction cost indexes or deflators. For years after 1957, this was done separately for irrigation and other project purposes, with results then added to obtain totals for all BREC facilities. The construction cost index for irrigation for the years 1958-75 is taken as the simple average of Bureau derived subindexes for storage reservoirs, pumping plants, canals, conduits, laterals and drains, and buildings. Required annual subindexes are from the report Construction Cost Trends (January 1975) prepared by the Bureau's Engineering and Research Center in Denver.

Before 1958 for irrigation, and since 1900 for all other purposes combined, construction costs are deflated to 1972 dollars according to either:

(1) the Engineering News Record (ENR) construction cost index (for 1900-24); (2) the ENR index averaged with various other indexes for water structures (for 1925-46); or (3) the BREC's own composite construction cost index (for 1947-75). This composite BREC index is updated in the above report Construction Cost Trends and also periodically in the Survey of Current Business, along with other national income and product data published by the Bureau of Economic Analysis (BEA) of the Department of Commerce. Beginning with the year 1947, the BEA accepts the BREC composite index as applicable to all publicly funded water conservation and development structures.

21/ The gross real investment in Bureau of Reclamation irrigation facilities is explained in note 20. It does not include projects since abandoned or written off with Congressional approval--considered in this study to be the only element of 'capital retirement' involved in the Bureau's irrigation program.

22/ Until 1950, net and gross capital values for Bureau of Reclamation irrigation facilities are the same. After 1950 net values are less than gross existing capital stocks (investments) by estimated cumulative expenditures for the rahabilitation of existing irrigation works. As of 1975 the real investment in rehabilitation programs has totaled about $100 million in 1972 dollars ($140 million in 1972 dollars). The expenditures to 1975 in historical dollars have been around $75 million. In this study BREC rehabilitation expenditures are considered to be analogous to depreciation allowances, in that both impose a demand on annual investment budgets but create no new capacity.

23/ 'Irrigable project acreage' refers to lands for which irrigation is feasible and intended and for which project works have been constructed and water is available. The definition is from official Bureau of Reclamation reports.

24/ 'Net acreage irrigated' is that part of the irrigable project acreage actually irrigated in any one year. This net acreage will include irrigated cropland harvested, irrigated pasture, cropland planted but not harvested, and the acreage in irrigation rotations used for soil-building crops. This definition is also from Bureau of Reclamation reports and is comparable to the net irrigated acreages discussed in table 6 and note 17.

25/ From column 7 in table 5. Also, different kinds of investment activities represented in on-farm irrigation facilities are listed in note 16. On-farm is interpreted to also mean farmer-ownership, even though some Federal investment was involved via cost-sharing.

26/ Gravity irrigation may require: (a) Open or covered canals or conduits, from which water is carried to fields in supply ditches and then turned directly or siphoned into furrows; (b) underground piping from water sources, with turnout valves for each major point of field supply; or (c) underground or overhead piping directly from water sources to the crops irrigated. As opposed to sprinkler irrigation, the essential point is that water distribution is by gravity flow. The water may first be pumped from wells and streams, may come from 'artesian' or free-flowing wells, or may simply be drawn from streams and reservoirs at points higher than the area to be irrigated.

27/ In sprinkler irrigation water is discharged under pressure through perforated pipe, stationary sprinklers, rotating sprinklers or various types of nozzles. Sprinkler systems are generally regarded as permanent, semiportable or portable with respect to needs for moving the distributing equipment independently of the pump or water source. Information is shown in table 10 on four variations: (a) Permanent installations and solid-set portables; (b) portable or semiportable systems moved manually; (c) towed or mobile equipment other than self-propelled center-pivot systems; and (d) center-pivot systems.

28/ Average on-farm investments per acre are shown separately for gravity irrigation (col. 2/col. 4) and for sprinkler irrigation (col. 3/col. 6). Because either type of irrigation method can require additional off-farm facilities, these averages are not valid for comparing the total cost of gravity versus sprinkler irrigation as alternative methods for applying water.

29/ Increase all gross and net data by 31.6 percent to obtain comparable estimates in constant 1975 dollars; internal percentages are not affected. The 1975/72 cost ratio for sprinkler equipment (131.6%) is from table 9. This ratio is relevant to tables 8, 9 and 10.

30/ Gross stocks approximate the cost of reproducing at constant 1972 prices those sprinkler irrigation facilities and equipment still on hand and potentially used. The net investment (net stock) is the estimated depreciated value of the facilities, also in 1972 prices. Percentages are of next-order totals. That is, for 1940 capital values for the water-supply versus distribution components of U.S. sprinkler systems were split 8.7% to 91.7% on a net value basis. Within 'water supply', the net capital values were split about 50% to water source and 50% to pumps and power units.

31/ Average useful lives for 'permanent' installations (distribution system only) are figured as 25 years, and for solid-set portables as 12 years. Water-supply and pumping-plant components are depreciated separately and over different periods. Some representative useful lives are 25 years for wells and stream improvements, 20 years for pumps, 20 years for electric motors, 15 years for diesel, propane or natural gas engines, and 9 years for gasoline or distillate engines.

On the matter of combining solid-set and permanent systems: True solid-set systems involve the use of enough portable pipe and auxiliary equipment to eliminate the need to move the system and, as might be expected, are sometimes more costly than permanent installations. However, all estimates in this column for before 1950 are for permanent installations.

32/ Recommended average useful lives for depreciating components of hand-moved sprinkler systems are 10-15 years for stationary aluminum pipe and valves, 5-8 years for movable aluminum pipe, and 4-8 years for sprinklers, depending on materials and design.

33/ This system heading combines information for units involving towed pipes and hoses, trailer-mounted rigs, wheel-roll devices, and any other mechanically-moved rigs other than center-pivot systems. An average useful life of about 12 years was used to depreciate these systems.

34/ The assumed average useful life in depreciating self-propelled center-pivot systems is 15 years. This type of system is shown separately because of its frequent adoption for irrigating large fields and its apparent great popularity in newly developing irrigation areas in Nebraska, Colorado, Kansas, Texas, Idaho and some Midwest States. By 1975 center-pivot systems were in use on about 30 percent of all U.S. farmland irrigated with sprinklers. They also accounted for about 30 percent of the net capital value of all sprinkling equipment on farms, excluding pumping units and wells and other water supply assets.

35/ Totals for 1975 include an estimated 190,000 acres of so-called 'drip' or 'dribble' irrigation, as well as gross capital stocks of $72 million and a net investment of $55 million in drip application equipment (in 1972 dollars). Over 93 percent of the drip irrigation acreage reported in the United States for 1975-76 was concentrated in California (65.6%), Texas (11.1%), Hawaii (9.0%) and Florida (7.4%). Drip irrigation itself has many variations. Basically it entails the use of low-pressure, small-diameter emitter tubes leading into the root zones of plants.

36/ The net agricultural area drained is determined by first adding up all land drained within organized drainage districts, county drains, other drainage enterprises, and irrigation enterprises active in drainage, then deducting nonagricultural lands drained within enterprises, then deducting farmsteads, roads, wasteland and timber or brushlands within farms drained, then adding drained cropland and pasture on those farms not within organized drainage enterprises. The Census of Agriculture and the Census of Drainage within it are the primary, though not the exclusive or at all adequate, sources of required acreage information, particularly for years since 1959. In this study the net agricultural area drained is broken down into that associated with irrigation and that not associated with irrigation. For convenience the latter is called 'farmland development drainage'.

37/ Acreages for farmland development, historically the predominant reason for drainage, are the net agricultural area drained less irrigation-associated drainage (col. 1 less col. 3).

38/ Investments in drainage facilities associated with irrigation are not only calculated separately from farmland drainage, but are included with irrigation and not with drainage in adding up natural resource investments. Irrigation-associated drainage refers only to special needs for major drainage works within irrigation projects or perhaps to the small amount of drainage without irrigation undertaken by a few irrigation organizations. Proper drainage merely incidental to farm irrigation systems is not analyzed separately.

39/ Averages per acre are obtained by summing col. 4 in this table with col. 1 in table 12 and then dividing by col. 1 in this table.

40/ Averages per acre are obtained as col. 1 in table 12 divided by col. 6 i table 12.

41/ Averages per acre for irrigation-associated drainage are obtained as col. 4 divided by col. 3 in this table. Averages for years before 1920 are not shown because low acreages for that early period produce unrealistically high investments per acre.

42/ In general, net values for all drainage facilities are estimated as accumulated investments to the year indicated, less investments in facilities abandoned to date, then less the accumulated depreciation of facilities or improvements still in use, all deflated to 1972 constant dollars. The net values are also exclusive of those drainage facilities specifically associated with irrigation.

In figuring depreciation on drainage facilities, on-farm drainage improvements were assigned an average useful life of 25 years with no salvage value and then depreciated at a uniform straight-line rate of 4 percent. Off-farm or group drainage works were handled quite differently because the available gross investment data were considered weak and unsuited to depreciation by any formal method. The 'procedure' was to assume that known capital outlays for replacement and rehabilitation of project drainage facilities could be considered equivalent to depreciation allowances. In effect this says that the gross investment for any year can be divided into two parts: (a) A replacement or 'depreciation' allowance, and (b) that remaining for the expansion of facilities. Part (b) is then assumed to be the annual net investment, and thus the annual change in the net capital value of the facilities. Obviously, for those years when investment in group drainage was insufficient to cover depreciation allowances thus estimated (1930-45), decline in net capital values necessarily occurred.

43/ Acres of farmland development drainage are repeated in table 12 to aid in assessing the significance of the averages in the next column.

44/ Capital stocks on soil and water conservation and watershed protection are given by 5-year intervals starting with 1935. To show recent trends and declines more clearly, annual figures are given for the period 1971-75. Before the mid-1930's, soil conservation programs and individual conservation efforts were fairly minimal. The Soil Conservation and Domestic Allotment Act of 1936 combined the objective of soil conservation with farm income supplements and authorized Federal payments to farmers under the ACP (later REAP) program for adopting conservation farming practices and installing conservation works. It and sundry other legislation provide the legal basis for the Federal Government investing in conservation on individual farms through various cost-sharing formulas and devices. The most important additional laws laws include the Agricultural Adjustment Act (1938), the Watershed Protection and Flood Prevention Act (1954, Public Law 83-566), the Agricultural Act of 1956 (the 'Soil Bank Act'), and the Great Plains Conservation Program (1956, P.L. 84-1021).

The net value of all conservation measures was determined by adding together the net values of measures installed and still remaining on farms under the REAP program, the small watershed program, and the Great Plains program. However, only those REAP and Great Plains farm conservation measures regarded as permanent by the administering agencies are counted. Watershed protection investments are confined to structural measures for land protection per se such as grade-stabilizing and critical-area-treatment structures, and to

critically needed nonstructural measures for land treatment--if they were not financed under the REAP, Great Plains or other cost-sharing programs. Also, irrigation and drainage investments undertaken through the REAP, Great Plains, or small watershed programs are added where appropriate into the previous estimates for irrigation and drainage (tables 5-12). They are not counted as soil or land conservation.

Annual current-dollar investments for farm conservation and watershed land protection were obtained from numerous sources, mainly including the Program Analysis Branch of the Agricultural Stabilization and Conservation Service, the Resource Development Division of the Soil Conservation Service, and the Natural Resource Economics Division of the Economics, Statistics, and Cooperatives Service, all in the U.S. Department of Agriculture. Their program reports, data and advice were supplemented by certain long-term or other annual data available in Agricultural Statistics, the Statistical Abstract of the United States, and miscellaneous other material.

As in the case of irrigation and drainage facilities, annual investments in farm conservation and watershed land protection measures were converted to constant 1972 dollars, summed to obtain cumulative gross investments, and then depreciated to obtain the net values given in this table. Useful lives for depreciation purposes were figured as 10-15 years for permanent soil conservation or land treatment investments made under the REAP or small watershed programs, 17 years for Great Plains soil conservation measures, and 50 years for structural measures for land protection installed under the small watershed program.

45/ Investments, gross stocks and net stocks are determined individually for each major conservation program and also for the farmer share versus the Federal share of capital outlays. Federal cost shares for soil conservation investments have averaged close to 50 percent under the REAP program since its start in 1936, and about 68 percent under the Great Plains conservation program since its start in 1957. The Federal share of capital outlays for land stabilization measures installed since 1954 under the small watershed program has averaged around 85 percent.

46/ Annual net investment is the algebraic (±) difference between gross annual investment and annual depreciation for all resource development activities combined. In years when gross investment is more than enough to cover annual depreciation on existing capital, net investment is positive and the net value of capital grows. If annual gross investment is insufficient to cover depreciation allowances, 'disinvestment' occurs. The net value of capital then falls by the amount of the deficiency.

The average annual rates of net investment in table 14 are based on the corresponding net capital values of table 3. For any resource investment activity or data column, denote the latter as K ($ billions), the average annual net investment rate by I' ($ millions), and any 5-year period by t (t = 1, 2, ... on up to 15 for 1971-75). Then--

$$I'_t = 1000 (K_t - K_{t-1})/5, \text{ in millions of 1972 dollars.}$$

For example, from table 3 for all resource development activities for the 1971-75 period,

$I'_{t=15(1971-75)} = 1000 (\$27.465 \text{ bil.} - 26.570 \text{ bil.})/5 = \$179 \text{ mil./yr.}$

This is the 1971-75 estimate in col. 1 of table 14. By applying the 1975/72 cost ratio of 135.2 in table 3, the $179 million in constant 1972 dollars converts to about $242 million in constant 1975 dollars.

47/ Separate average annual net investment rates are calculated for soil and water conservation and watershed protection measures from 1956 on, especially since the former have become increasingly negative. See table 13 (col. 4) for the declining net capital values of conservation measures installed under the Rural Environmental Assistance program.

48/ Apply the 1975/72 cost ratios in table 3 to go from 1972 to 1975 dollars.

49/ The comparative average annual net rates of investment for all forms of fixed agricultural capital are calculated by the same procedure explained in note 46 for natural resource activities. The aggregate net rates result from adding the different rates given in this table. They may not agree exactly with direct calculations made from table 1.

The basic estimates of net capital stock values are in table 1 for each type of asset. Average annual rates of net Federal investment for natural resource development and conservation carry without change from table 14 into table 15 because capital accumulation for ordinary farm structures or equipment has not relied importantly on Federal financing. On the other hand, private investment has been important for accumulating natural resource capital as well as farm buildings and equipment.

50/ Apply the 1975-72 cost ratios in table 1 to go from 1972 to 1975 dollars.

51/ Cumulative gross investments at any time will be more than the gross or reproducible value of facilities then existing--the gross stock of capital--by the reproducible value of facilities and equipment abandoned, retired or fully depreciated up to that time. Accordingly, the estimates in this table exceed the reproducible real cost of existing facilities for irrigation, drainage or conservation. Information on cumulative gross investments is useful for historical purposes, in appraisals of the effectiveness of public cost-sharing programs and, of course, for estimating the gross investment rates discussed in comments 46 and 52.

52/ Annual gross investment rates by periods are given for all resource conservation and development activities combined. Computations follow the kind of formula given under note 46. For example, the average annual gross investment rate (I) during the period 1971-75 was $ 915 million per year (in 1972 prices). Alternatively in 1975 prices, the average annual gross investment from 1971-75 in agricultural irrigation, drainage and conservation amounted to $1.25 billion.

53/ The 1975/72 cost ratios in table 3 apply only roughly when converting annual gross investments for the years 1971-75 from 1972 to 1975 dollars.

54/ Data on farm population, employment and labor use are available in numerous Census and other agency reports and other agricultural publications. Annual figures starting with 1929 are in the Economic Report of the President, published each January. The same data going back to 1910 and earlier appear in various issues of Agricultural Statistics, published each year by the U.S. Department of Agriculture, and in the Statistical Abstract of the United States, published each year by the U.S. Department of Commerce.

55/ From annual or other series maintained by the Economics, Statistics, and Cooperatives Service (USDA), based primarily on the periodic 5-year Census of Agriculture and annual studies of ESCS.

56/ All land used for agriculture is estimated from all reported land in farms, less farmsteads, roads, forest and woodlands if not grazed, less idle cropland, and less cropland in temporary retirement or soil improvement programs, and then plus land not in farms but used chiefly for grazing, whether open or forested. Some land not within farms is leased for cropping. However, on a national basis the acreages involved are minor and updated only infrequently.

PART III. SELECTED REFERENCES ON NATURAL RESOURCE CAPITAL

Introduction

This specialized reference list includes more than 350 formal publications and other references. All are recommended for understanding the measurement, significance and contribution of natural resource capital accumulation to the growth and development of agriculture in the United States. There is no effort to include only the relatively recent or so-called up-to-date material. Doing so would erroneously leave out some of the most valuable literature bearing on capital growth in agriculture. Moreover, dates of publication of research and other information documents, such as Census reports, often belie their true substance, from an historical as well as other viewpoints.

Irrigation, drainage, and conservation assets (IDC) are the main components of natural resource capital covered. However, the compilation also includes some key references on flood protection, environmental controls, energy topics, and agricultural research. These subjects and associated policy issues also impinge on agricultural growth and development, either conjunctively or competitively with the IDC assets and the more ordinary forms of capital like land, buildings and farm equipment. For completeness natural resource capital must be studied in the context of agricultural growth and capital accumulation in general.

In many respects the most useful work bearing on natural resource capital accumulation in agriculture is the pathbreaking analysis of Tostlebe (1954) on the growth of physical capital (encompassing real estate, equipment, inventories) in agriculture from 1870 to 1950. There is also the Towne-Rasmussen analysis (1960) of gross farm product and investment in the nineteenth century. Significantly, both of these studies were completed in the U.S. Department of Agriculture for the National Bureau of Economic Research. This Bureau and, later, the Brookings Institution have sponsored much of the basic economic research on growth and productivity in the United States. Their reports are included in the sections on growth and productivity for the economy as a whole and for the farm sector. See especially Denison (1974).

Concerning organization, the individual items are classed into eleven specialized lists, but only the first seven groups are true subject-matter separations. They involve: capital and investment in general, economic growth and productivity, separated for the economy as a whole versus agriculture; general aspects of land use and resource development policy, mathematical/statistical techniques and evaluation methodologies, and representative survey studies of natural resource investment. The seventh list is for the items used in developing capital stocks of specialized irrigation equipment and on-farm irrigation water supply facilities, a hitherto neglected area of agricultural research.

This overall classification was not entirely clearcut of course, but worked very well. Doubts on the best placement of some items were resolved by repeating them in the competing categories. A few works considered to have exceptional policy, methodological or empirical value may appear in several categories. Prime examples are Ward's monograph on capital measurement and the definitive text of Maass and Anderson (1978) on irrigation in its fundamental evolutionary, operational, sociological and economic dimensions.

The last four lists are for government publications and reports, arranged according to the issuing Departments and their member agencies. Three executive Departments (Agriculture, Commerce, and Interior) have produced nearly all the research, statistical and other Federal information bearing on capital accumulation in agriculture. Publications of universities, experiment stations, and various State government units can be found under the appropriate subject areas. The general government category contains Congressional as well as some useful international references.

Commentary on the USDA Literature

Some special remarks are in order concerning the 100 or so Department of Agriculture items in this detailed bibliography. The USDA section, beginning on page 73, includes individually authored or agency authored official Department publications. But the list also includes pertinent items published outside of the Department--in various professional journals, cooperative USDA/State Experiment Station bulletins, and other media--if the authors were Department of Agriculture employees or were known to have conducted their work with Department support. Most of the USDA items appear again within the major subject-matter classes. Those which do not are not less useful; by and large they contain important statistical information not readily lended to the particular breakdown employed.

The two-way treatment of USDA materials in effect makes Part III of this staff paper two complete bibliographies on natural resource capital in agriculture. One covers the subject in general and the other the U.S. Department of Agriculture's particular contributions toward the understanding of such a broad and important subject.

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